INSECT ARTIZANS AND THEIR WORK

EDWARD STEP, F.L.S.

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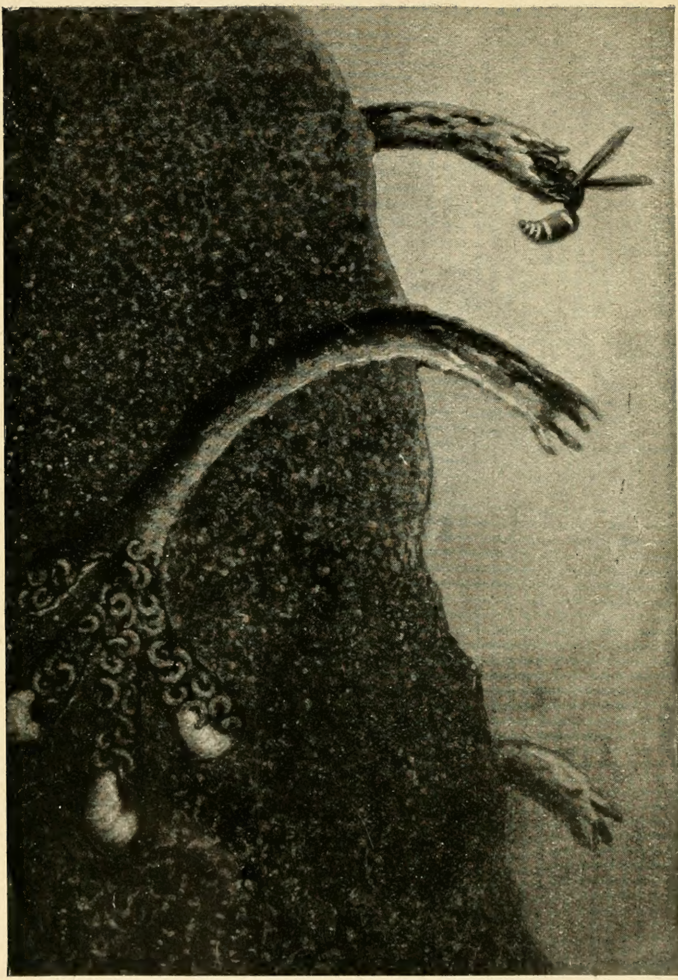

PLATE I — NESTS OF MASON-WASP. — *Frontispiece*

Odynerus tunnels into banks and provisions her cells with caterpillars. Whilst the work is in progress she constructs curved tubes of the excavated material to keep out the ruby-tailed wasp, which is a parasite. (See p. 72.)

Drawn by T. Carreras.

INSECT ARTIZANS AND THEIR WORK

BY

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INTRODUCTION

No one who has devoted any considerable part of his open-air leisure to the observation of living insects can fail to be struck by the fact that each species has its own definite method of life, its own way of doing things, and, in the construction of a shelter for itself or its progeny, its own preference for materials and its own mode of using them. These are the methods and preferences not of the individual, but of the species; and the individual needs no apprenticeship, but goes directly to work with the experience it has inherited from an enormously long line of ancestors. In an earlier period of our civilization the son followed the vocation of his father, taught by him, and inheriting the secrets of the craft. Many of our surviving surnames are due to this fact, the names of Smith, Taylor, Fletcher, Bowyer, and the like becoming permanently attached to the families pursuing these crafts and mysteries. In the case of the Insects, the parents cannot instruct their offspring, for as a rule they never see them. One marvels at the skill displayed by the bird in constructing its first nest; but it may be said that the newly mature bird has at least a chance of watching a second-year matron of its kind building, and getting some hints that way. In the case of the Insects there is as a rule, no possibility of such help. In the vast

majority of species the parent is dead long before the daughter comes to that stage of existence when the necessity for making provision for her progeny arises; so the knowledge has to pass by way of transmitted memory. Somewhere in the minute speck of protoplasm constituting the egg of one of the Solitary Bees, there is an infinitesimal particle of nerve matter which contains the secret of how to cut accurate circles and ovals of rose-leaf so that a number of them will overlap and curve into a perfect cylinder. During the greater part of its life the creature that hatches out from that egg will have no need of the secret, but the germ of it will go on developing, and when the insect has attained to the complete bee form there is the idea in the memory cells ready to instruct the nerves that govern the action of wings and legs and cutting jaws.

Here is a marvel which should make us keen to follow with interest the industries of these little creatures. It is only one example of the thousands of marvels that reward the inquirer into Insect Economics. With a view to awakening an interest in these matters, the following pages have been written; and the better to attract the attention of those to whom a more systematic treatment would be considered dry and uninteresting, the examples chosen have been grouped under headings borrowed from the human industries that most nearly correspond to the activities of these Insect Artizans.

I

SPINNERS AND WEAVERS

I

SPINNERS AND WEAVERS

From very early times man has been acquainted with, and has made use of, the spinning powers of insects. The Silkworm, that came originally from China or India, has been the principal source of the finest raiment with which the human species has clothed itself, but the faculty of producing silk is shared by many insects in a minor degree. In most of them it is utilized in the final stage of the grub state to make provision for the security of the chrysalis, but many caterpillars possess it already when newly issued from the egg. As an example of this we may cite the case of the young caterpillar of the Puss Moth (*Dicranura vinula*), which feeds upon the upper surface of the leaves of sallow, willow, and poplar. The last named are not only glossy, affording an insecure foothold, but are kept in a state of constant fluttering by the slightest movements of the air. The tiny caterpillars, looking like smuts that have clung to the leaf, and that might be detached by a breath, at once set to work to spin a little pad of silk on the leaf, in which the hooks of their feet may catch and so enable the

animated particle to feed in safety, no matter how violent the jerking of the leaf from side to side.

Another simple, but highly useful, example of the spinning power is exhibited by leaf-rolling caterpillars (*Tortrix*) and the elongated caterpillars known as Geometers from their peculiar manner of progression, in which they appear to be carefully measuring the distance traversed. Some caterpillars of these two families, when the bough upon which they are feeding is rudely jerked, at once loose their hold and simultaneously spin a single thread by which they hang suspended in mid-air until the supposed danger has passed, when they ascend the thread and regain their former station.

These same leaf-rollers depend largely upon their power of spinning threads for the skill with which they accomplish the neat leafy tube which is at once a house and a dining-table. If we walk, in May or June, through an oak wood, we shall see a number of these caterpillars hanging by silken threads which are only made visible to our sight by their reflecting the sun's rays. Tracing one of these gleaming threads upward, we shall see that it depends from the open end of an oak leaf that has been rolled into a tube, and if we wait a few minutes we shall see the wriggling larva after climbing up by its thread disappear into the green tunnel. Plucking a rolled leaf, we find that the coils are held in position by a great number of threads which stretch like tent-ropes from the curved to the

flat portions of the leaf. By pressing upon these threads with the weight of its small body, the caterpillar gives a further turn to the coil, and prevents its springing back by attaching a short new thread at an angle between the old thread and the leaf. Other threads are attached farther up the coil and farther out on the leaf, and these are shortened and tightened in a similar manner, until the little Green Tortrix larva has rolled up sufficient of the leaf for its purpose.

If the young leaf has so far hardened that the midrib has too much spring in it, the caterpillar overcomes this tendency by reducing its thickness and its resistance with its jaws. In this tube the caterpillar lives, feeding upon the inner folds of its house, and when it has attained to its full development, as a larva, spins a slight cocoon and changes into the chrysalis condition, from which a little later it emerges as the beautiful little moth with pale green wings known as the Oak Tortrix (*Tortrix viridana*). This is the insect that in some years almost entirely defoliates our oaks before midsummer, though apparently without inflicting any serious damage to the tree, which is soon well clothed again.

Similar rolled leaves may be found upon many trees, the work of other species of *Tortrix*, which pursue their industry upon similar lines by the use of the simple silken thread. In some cases, however, the same end is attained in a more simple manner—the edges of the leaf being spun

together before they expand, so that the result is a flat bag. Everybody who has grown rose-trees is familiar with examples of this use of the silk thread; another common species treats the apple-leaf in similar fashion, and in other cases several leaves are spun together with the same object in view—the hiding of the destructive caterpillar until it has developed into a moth.

A most remarkable example of an insect that cannot make silk using another that can for its ends is afforded by an Asiatic ant (*Œcophylla smaragdina*). This ant haunts the foliage of trees, and is desirous of having shelters among the leaves; but as it is not a spinning ant (there are such), it has brought what looks like intelligence to its aid, and got its desires satisfied partly by proxy. Ant-larvæ have the power of spinning silk which is necessary for the construction of the cocoons in which they pass the chrysalis stage of their life-history. A party of ants hold together the edges of leaves which they have decided are to form the shelter, and whilst they are so held other ants come up from the nest, each with an ant-larva in its mouth. The desire of its adult relations is by some means conveyed to it, and it produces a sufficiency of fluid silk to connect the edges of the leaves together.

Several Indian species of ants (*Polyrhachis*) build their nests on the upper side of leaves, or between two leaves. These consist of a single cell, and those that are fully exposed on the surface of the

leaf are covered with fragments of leaves and other vegetable matter to make it less obtrusive. But the point to which we desire to call attention is that the ant lines these nests with silk of its own manufacture, and of a texture similar to spiders' web.

The chief spinners, however, are the caterpillars of the butterflies and moths, especially of the moths. As a rule the spinning of butterfly caterpillars is restricted to the fabrication of a silken pad, into which the terminal hooks of the chrysalis become attached, and of a girdle around what we may term the waist of the chrysalis. There are exceptions, as we shall show. The fluid silk is produced by two large glands, one on each side of the body, whose ducts unite and are continued externally as the spinneret, which is a point on the middle line of the lip, differently developed in the various families and species. The glands are of simple structure, and vary in size according to the amount of silk-production required by the species. In some of the moth-caterpillars that elaborate thick cocoons their length and weight are considerable: the Silkworm, for instance, possesses a pair of silk-glands (*sericteria*) each measuring five times the full length of the body.

This length is exceeded in some other species. In the full-grown Silkworm their weight equals two-fifths of the insect's total weight. This is not surprising when one considers the great length of thread that is produced in the weaving of the cocoon.

The average length of silk wound off from a single cocoon is 1,526 feet; but there is a difference between the produce from a cocoon containing a female chrysalis and one containing a male sufficient to enable the silk-farmers to sort out the sexes by the weight of the cocoons. In agreement with this result it is found that a Silkworm that is to develop into a female moth has larger silk-glands than one that is to become a male moth.

The history of the domestication of the Silkworm, like that of the Honey-bee, extends so far back that its beginnings are hidden in the mists of antiquity. Silk is known to have been in general use among the Chinese at a period compared with which the introduction of the insect to Europe may be spoken of as recent. Silk tissue reached Europe from Asia long before anything certain was known here as to its origin, "some supposing it to be the entrails of a spider-like insect with eight legs, which was fed for four years upon a kind of paste, and then with the leaves of the green willow, until it burst with fat; others that it was the produce of a worm which built clay nests and collected wax; Aristotle, with more truth, that it was unwound from the pupa of a large horned caterpillar.

"Nor was the mode of producing and manufacturing this precious material known to Europe until long after the Christian era, being first learnt about the year 550, by two monks, who procured in India the eggs of the Silkworm moth,

with which, concealing them in hollow canes, they hastened to Constantinople, where they speedily multiplied, and were subsequently introduced into Italy, of which country silk was long a peculiar and staple commodity. It was not cultivated in France until the time of Henry IV, who, considering that mulberries grew in his kingdom as well as in Italy, resolved, in opposition to the opinion of Sully, to attempt introducing it, and fully succeeded" (Kirby and Spence).

There are several silk-producing moths of larger size of which great hopes in a commercial sense have been held, but, with the exception of certain Indian species which supply the Tussore silk and Eri or Arindy silk, the results have been somewhat disappointing. These big silkworms belong to a family different from that which includes *the* Silkworm. They are more closely related to our own Emperor Moth (*Saturnia carpini*), whose beautiful green-and-pink caterpillar spins an elaborate cocoon that has long been famous among insect structures. The upper part of this cocoon is so contrived by the untaught caterpillar that its exit when it becomes a moth will be easy, whilst entry on the part of any intruder will be the reverse. At this upper part the cocoon is not closed, but tapers to a point formed by straight silken hairs converging. These may be pushed against from outside without yielding, but very slight pressure from within will serve to separate them and reveal the opening. At a little distance inside this structure

is repeated, so that the chrysalis reposes behind two puzzle-doors which oppose no obstruction to the moth.

In a North American species of Silkworm (*Platysamia cecropia*) this type of cocoon is improved upon. There are in fact two cocoons, one inside the other, with a packing of loosely spun threads between the two walls, which keeps the inner cocoon in place, and must protect the contained chrysalis from great changes of temperature. But this arrangement, though admirable for the chrysalis and the moth, is not appreciated by those who would convert its filaments into woven tissues. The open upper end of the cocoon makes it a difficult matter to unwind the silk, and so it does not appear to have a high commercial value, though it is said to have been successfully woven into stockings. As the cocoon is three inches or more in length and nearly an inch and a half broad, one would expect that the extra quantity of silk would make up for this defect. In California, however, a smaller species of the same family is reared for the sake of its silk much as the Silkworm of the Old World is.

The Cecropia Moth, as may be supposed from the dimensions of its cocoon, is a large insect. When the moth spreads its beautifully ornamented wings, the distance between the tips of the forewings is about six inches; and the caterpillar that spins the big cocoon is four inches long and nearly an inch in thickness. It is gloriously coloured with a

PLATE 2 COCOONS OF A SILK-MOTH. Page 10

Three cocoons of the Cecropia-moth, the lowest example cut open to show structure and chrysalis. It will be seen that there are really two cocoons of firm texture with an intermediate packing of looser silk. The provision for easy exit of the moth is also evident.

Photo by Author.

PLATE 3 — MIXERS OF SILK AND WOOD-FIBRE. — Page 12

The caterpillars of the Dragon-moth and the Puss-moth both weave fragments of wood into the silk of their cocoons. The Dragon chrysalis is furnished with a hard, sharp spine on its head, which it rotates and so cuts out an exit for the moth. In the photo this "tin-opener" still adheres to the head of the moth. In the second photo the hard cocoon of the Puss-moth is cut through to show its thickness and the contained chrysalis.

beautiful green shaded with blue, and from each of the rings or segments of its body there stand out five stout fleshy spines of red, blue, and yellow, some of them knobbed, and the knobs supporting sharp black bristles.

There are several other large moths, both in America and India, that produce large silk cocoons of varying texture. In that of the Cecropia Moth the outer portion is so closely woven and the interstices filled in with liquid silk that it is as tough and firm as vellum; the inner cocoon is of similar consistence, though thinner. An Indian species is described as having the cocoon of leather-like consistence, and Colonel Sykes says it is cut into strips by the Mahrattas and used as thongs to bind the barrel and stock of their guns together. Some of the insects that have to make their way through such resisting cocoons when they reach maturity are helped by the chrysalis having a sharp spine in front of the head, with which the more solid envelope may be pierced. In others the emerging moth discharges an alkaline fluid which dissolves the silk at the top of the cocoon and allows the insect to break through.

Our native Puss Moth (*Dicranura vinula*) resorts to this method of getting free from the strong box in which the remarkable caterpillar immured itself. To make this cocoon the Puss caterpillar gnaws a depression or enlarges a crevice in the bark of a tree, and builds over itself a skeleton dome of silken net. All over the surface of this net it attaches the

fragments of rasped bark and cements the whole with a plentiful supply of liquid silk which sets very hard. If one of these caterpillars is put into a glass vessel, so that there is nothing it can gnaw for this purpose, the resulting cocoon will be transparent and glass-like.

A section cut from one of these cocoons is not to be distinguished—even with the aid of a pocket lens—from actual bark. It may therefore be questioned whether it should be included among spinners and weavers; but the first stage at least is pure spinning, and the finished article shows how the product of the silk-glands may be utilized to elaborate a structure wholly different from the ordinary web-cocoon. The head end of the cocoon is said to be made of thinner material than the rest, the object being to offer less resistance to the emergence of the moth.

But this is not invariably the case. At the time of writing these lines we have opened a Puss cocoon from which no moth had emerged, and found the upper end of the cocoon actually much thicker than the other parts. The moth had succeeded in throwing off the chrysalis skin, but had evidently been unprovided with the dissolvent fluid, for there was no sign of its action on the glazed lining of the cell. So the insect had perished. To the same end the front part of the chrysalis skin has a low sharp ridge with which it cracks the cocoon, and this part of the skin remains attached to the moth's head until after emergence. The reason for this

appears in the secretion by the moth of a strongly alkaline fluid which softens the cracked cocoon sufficiently to enable the insect to push through; but a fluid sufficiently strong to so act on this hard material would probably injure the moth if its head were not protected by this cap. Several of the near relations of the Puss Moth make similar, though smaller, cocoons on bark, but others descend to earth, and these caterpillars spin only a flimsy cocoon, sufficient to hold the surrounding earth particles together.

One of the caterpillars of the Puss Moth group—the Dragon (*Hybocampa milhauseri*)—constructs a cocoon of the solid silk kind, and to effect the exit of the moth the chrysalis is provided with a hard head-spine. The cocoon is made to fit the chrysalis closely, so that when the time comes for the emergence of the moth the chrysalis is able to rotate the fore-part of its body, and the spine thus travels over the same part of the cocoon until it has cut out sufficient space to allow of the moth's exit. The process—which has been fully described by Dr. T. A. Chapman—is helped by the pouring out of a softening fluid guided to the right place by the same spine.

The caterpillars of the Oak Egger family spin firm, close-textured cocoons of an oval shape, mostly attached to twigs or leaves, and with the hairs from the spinner's body interwoven with the silk. These cocoons are in some cases given the appearance of egg-shell by the caterpillar ejecting

on the silk a fluid containing oxalate of lime, which hardens and gives the chalky appearance. The caterpillars of the Tussock Moth family, which includes the Gold-tail, the Gipsy, and the Vapourer, also mix hairs with the silk, but the cocoons are less substantial than those of the Eggers; and in the Tiger Moths they are still more flimsy, the chrysalis in some cases being plainly visible through them.

The butterfly-like moth *Castnia eudesmia*, of Chili, comes from a caterpillar that is still more sparing in its use of silk. Though its cocoon is five inches long, it is composed mainly of twigs, leaves, and other vegetable matter merely bound together with silken threads. In this respect it comes close to our Goat Moth (*Trypanus cornus*), whose huge and strong-smelling caterpillar, after several years spent in the interior of trees, wanders out and constructs a cocoon which is largely made of rotten wood fragments held together by silk.

The two little moths known as the Festoon (*Limacodes testudo*) and the Triangle (*Heterogena asella*) issue from roundish cocoons attached to leaves and twigs of oak, that look more like vegetable galls than silken structures. The cocoon is furnished with a distinct hinged lid which opens on the pressure of the emerging moth. The related American species, *Lagoa opercularis*, constructs a similar cocoon.

In the familiar Burnet Moths (*Zygæna*) the silk is so closely woven and varnished with liquid silk that the long spindle-shaped cocoons are parch-

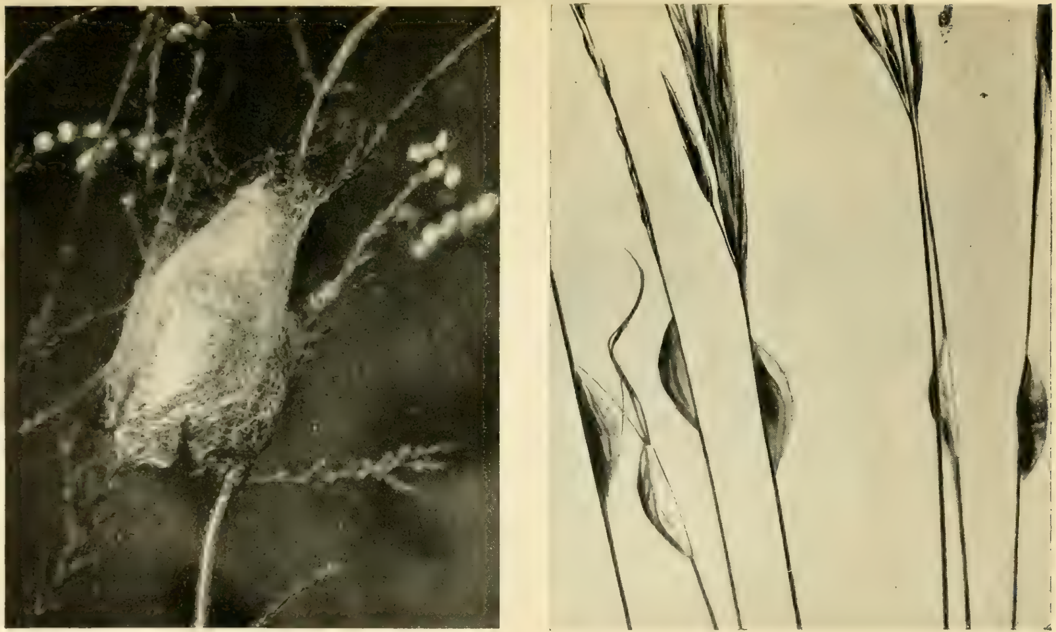

PLATE 4 — SILKEN COCOONS. — Page 14

To the left is the cocoon of the Emperor-moth with an arrangement of silk hairs in the upper end which permits of the exit of the moth, but prevents intrusion. To the right are the firm-textured cocoons of the Burnet-moth attached to grass-stems.

Photo by Author.

PLATE 5 — SOME SCARABS. — Page 50

Beetles of this type are miners in the earth, and their legs are developed into efficient digging organs, whilst the head is often broad and flat to serve as a shovel. They bury manure for the nutriment of their grubs.

Photos by Author.

menty, and crackle when touched. The chrysalis contrives to force its way half out of the upper end just prior to the emergence of the moth.

Although the butterflies as a class are contented with a pad of silk for the chrysalis to hook its tail in, and a silken girdle round its middle, there are a few whose caterpillars spin cocoons. Such is the case with the Grayling Butterfly (*Satyrus semele*), although it must be confessed that the silk is reduced to the minimum—just sufficient to hold the earth particles together. The caterpillars, too, of the Skipper Butterflies spin a slight cocoon, as a rule drawing together a few of the leaves of the plant upon which they feed.

The caterpillars of some moths as soon as they leave the egg combine to weave an extensive sheet of silk around the twigs of their food-plant, enclosing a considerable number of leaves upon which they can feed in safety. A very familiar example of this class of spinner is the little grey moth *Hyponomeuta padella*, which often strips hawthorn hedges completely of their leaves, and the twigs are bare save for the caterpillars' extensive sheets of webbing. It is remarkable that, throughout their larval existence, the caterpillars hatched from one batch of eggs will keep together under the protection of their own common tent. An allied species, *Hyponomeuta cagnagella*, makes havoc of the spindle-tree, and of the garden Euonymus, under similar protective webs.

Other species construct these webs for their

protection during their infancy only; later the caterpillars disperse, and each continues to lead a separate existence thereafter. Of this group is the caterpillar of the Lackey Moth (*Malacosoma neustria*), which, however, keeps up the communal habit until it is of considerable size. They issue from the tent to feed upon the surrounding leaves. Often when the sun is shining they may be seen clustered on the exterior of the tent as though enjoying a sun-bath. When about to change their skins they usually seek the retirement afforded by the tent. These structures do not present the finished appearance of the cocoon and do not suggest the skilled worker as that does. In fact, they are generally passed by as being of the same character as the dusty sheets spread across obscure corners by the big house spider.

The young caterpillars of several of our butterflies construct similar tents for common protection. Thus the larvæ of the Marsh Fritillary (*Melitæa aurinia*) soon after they escape from the eggs in July spin together the leaves of devil's-bit scabious, connecting them by sheets of gauzy webbing, and under the tent so formed they feed in company. When all the leaves in this tent have been robbed of their nutritive parts, the company abandons this dwelling and moves off to another plant, which they surround with a larger structure than the first. Towards the end of summer they leave this in turn and retire to the lower parts of the plant, where they construct another web, become sluggish,

and pass the autumn and winter in an inactive condition; but as soon as vegetation becomes active in spring these caterpillars throw off their sluggishness and leave their winter shelter. Each now goes his own way and lives independently of his fellows. The caterpillars of the Glanville Fritillary (*Melitæa cinxia*) adopt a modification of this plan. They live in company, and when about a month old spin a common tent in which they pass the winter, leaving it in spring, when they separate somewhat.

The eggs of the Small Tortoiseshell Butterfly (*Vanessa urticæ*) are laid in a batch of sixty or more on a terminal leaf of stinging nettle, and as soon as they are hatched the tiny caterpillars set to work spinning a tent which includes a number of leaves, and as these are eaten by them they extend the bounds of their tent to include more food. Here they remain in company until more than half-grown, when they separate. The Peacock Butterfly (*Vanessa io*) and the Camberwell Beauty (*Vanessa antiopa*) follow a similar method in the larval stage; but the caterpillars of the Red Admiral (*Pyrameis atalanta*) and the Painted Lady (*Pyrameis cardui*), whose eggs are laid singly, naturally follow a different course, though they are both spinners. Each young caterpillar constructs a habitation for itself, by connecting the edges of the leaf upon which it was born with another leaf on the stem of the plant—the Red Admiral on the nettle, the Painted Lady on the thistle.

Though we propose to deal with bees in a later chapter, under the head of workers in wax, it should be noted here in passing that the bee grub, or larva, is a spinner. The worker bees provide it with a cell of wax and with its food, but before becoming a chrysalis the larva constructs a cocoon by lining its cell with fine silk.

II

MINERS

II

MINERS

THE mining industry is very strongly represented among the insect races. Its exponents practise many diverse forms of the art, some crude, others highly specialized. Some insects are miners from their birth, others take up the craft only when they have reached maturity, and do so then not as a means of subsistence for themselves, but solely for the purpose of providing for a progeny that they will never see. One of the most astonishing things to an observant entomologist is the sight of the little bees of the genus *Andrena* busy sinking their vertical mine-shafts into a path that has been beaten down to make it uniformly firm and level, and trodden by feet innumerable. Try with your fingers or your pocket-knife to excavate such a hole yourself, with all a man's strength, and you will acknowledge that your best efforts only make a very sorry job of it. The little bee has only her slender legs and her jaws to help her in this work, but she loosens the little stones and the hard compacted soil, and gets it out bit by bit, and in a remarkably short space of time has sunk her mine to a depth of four inches or more.

Well might Kirby and Spence exclaim: "No circumstance connected with the *storge* of insects is more striking than the herculean and incessant labour which it leads them cheerfully to undergo. Some of these exertions are so disproportionate to the size of the insect, that nothing short of ocular conviction could attribute them to such an agent. A wild bee or a *Sphex*, for instance, will dig a hole in a hard bank of earth some inches deep and five or six times its own size, and labour unremittingly at this arduous undertaking for several days, scarcely allowing itself a moment for eating or repose. It will then occupy as much time in searching for a store of food; and no sooner is this task finished, than it will set about repeating the process, and before it dies will have completed five or six similar cells or even more. If you would estimate this industry at its proper value, you should reflect what kind of exertion it would require in a man to dig in a few days, out of hard clay or sand, with no other tools than his nails and teeth, five or six caverns twenty feet deep and four or five wide—for such an undertaking would not be comparatively greater than that of the insects in question."

If we carefully dig around one of these mine-shafts—no easy matter, for any tools we use appear to be too clumsy for the purpose—we shall find that they end in a round or oval chamber at the side of the shaft. In this, if the miner's work is finished, there is a compact ball of pollen, on which is an egg or a newly hatched grub. The pollen is just

that amount of food necessary for the grub until it attains to that stage of development when it is fit to enter upon the fasting pupal period in which will be formed the wings and other organs of the perfect bee.

The species of *Andrena* are much like small Honey Bees, but they are solitary in their habits, and have short tongues. They form a large genus —about fifty species are found in the British Islands —but their habits are very similar. They are very noticeable in spring, for it is then that they set about their mining operations; when they are busy collecting pollen from the early flowers they are more likely to be set down as Honey Bees and therefore too ordinary to be particularly noticed. The mines in the different species vary from five to ten inches deep. The little black bees of the small genus *Panurgus* agree generally in their habits with *Andrena*.

The Hairy-legged Miner (*Dasypoda hirtipes*), a near relation of the Andrenas, has had its industrial operations chronicled at length by Hermann Müller, who says the excavating work is performed by the bee's jaws. It sinks a perpendicular shaft like *Andrena*, only much longer—in this case extending to a length of a foot, or even two feet. Its hairy body and limbs are useful adjuncts, for after loosening the soil with its jaws it carries the particles out of the burrow by walking backwards and so sweeping them out at the entrance. Before going back for another spell of digging it distributes the expelled

material over a comparatively wide area, so as not to be incommoded by it being too near the pit mouth at this stage. This is effected very rapidly, but methodically, by means of its fore and hind legs, whilst the movements of the bee, as a whole, depend upon the middle pair of limbs. The front pair of legs in one second make four distinct movements backwards, throwing the soil under the body where it can be reached by the hind legs, which are stretched outward in a manner that sweeps the earth to each side. Then the bee returns to the hole, digs out more earth, hoists it out, and distributes it as before.

Müller found that each excavating operation took a minute or two, but the distribution of the soil was effected in fifteen seconds. As the shaft gets deeper, so a corresponding increase of the time is required for getting up the débris; and when at length the full depth has been reached there are the brood-chambers to be excavated. These number from three to six, and the first made is at the bottom of the shaft. The provisioning of this cell with pollen is completed before the second one is dug out. For this work *Dasypoda* is well organized. Her hind legs are densely coated with long hairs, and able to hold a great quantity of pollen. It has been ascertained that a normal load of pollen is equal to half the bee's own weight, and six of such loads are required to properly provision one cell. With a little honey to bind it, this pollen is kneaded into a ball. Then a further load of pollen is

gathered, mixed with honey and spread as an outer layer over the mass, which now has three feet, fashioned apparently to prevent its rolling and injuring the bee-grub.

Dasypoda now lays an egg on the top of it, and leaves it whilst she excavates her second chamber. With the material resulting from this work she closes up the entrance to the first chamber, and so saves the labour of carrying it up to the top. In like manner she excavates and provisions the other chambers, laying an egg in each. The pollen-mass is in each case over a hundred times the bulk of the egg, and is just sufficient to satisfy the food cravings of the grub that is to issue from the egg a few days later. The outer layer of the food-ball, with its extra proportion of honey, is evidently more suited for the first digestive efforts of the infant grub, for it eats evenly all round before attacking the less sweetened pollen of the central mass. All the waste due to the vital processes is retained by the grub until all the food is consumed, and then it is voided *en bloc*. By this arrangement there is no danger of the unconsumed food being polluted, as must otherwise happen. The larva having finished eating, casts its skin, and lies quiescent until the following year, when it becomes a chrysalis and finally a bee.

Another group of these short-tongued solitary bees is the genus *Halictus*, whose numerous species are all small, some indeed being the smallest of all bees. Some of these may be seen on emerging

from the underground cells where they have lain dormant through the winter. There is this difference in the habits of *Halictus* and *Andrena*, that certain work is done by *Halictus* in common. A number of females unite in excavating the shaft, and then each one builds her own set of cells unaided. Instead of each cell being a separate chamber opening out of the shaft at different levels, the cells of one worker form a mass in a common vault—an enlargement of one part of the shaft which, however, is continued far below the level of the vaults. The object of this downward extension is probably the better drainage of the vault. The entrance shaft is only wide enough for one bee to pass in or out at one time, but as several workers are engaged, this would lead to much loss of time and confusion if special provision were not made. This takes the form of an enlargement of the width not far from the entrance, and allows two bees going in opposite directions to pass each other. Some species make branch corridors from which the vaults of each worker open. The cells are oval and lined within by a coat of liquid silk or varnish. The winged bees emerge from these cells in September; but the males are all killed by the autumn frosts, whilst the females continue to live underground through the winter, emerging from their mine-shafts in spring and setting to work at once to enlarge the colony or to start new ones. Their mining operations are pursued at night, especially in moonlight.

Bees of the genus *Colletes* dig burrows often eight or ten inches deep. Although solitary bees in the sense that each sinks her own shaft and provisions only her own cells, yet they are gregarious, large numbers of them mining into one small area. Sometimes it is a clay-bank, a vertical face of weathered sandstone, or the mortar between the masonry of an old wall. The shafts are filled with a succession of cells in line—from two to eight—each provisioned with a paste of pollen kneaded up with honey. The cells themselves are formed by a secretion from the bee's mouth, which dries and hardens into a film much like gold-beater's skin. Three or four layers of this delicate substance can be separated with care from each cell—more from the ends. When the last cell is completed the shaft is closed with grains of sand or earth. *Panurgus*, of which we have two species, sinks vertical shafts, each containing six cells.

Eucera longicornis, whose male is notable for the length of its antennæ—as long as its body—frequents loamy and sandy soils, and sinks a shaft six or eight inches deep. At its termination it hollows out an oval cell, and apparently treats the walls with its saliva to prevent the absorption of the mixture of pollen and honey that is stored for the grub. Like *Colletes* it is gregarious in some localities, though not in all. Three of our species of *Anthophora* likewise mine in the ground, but the other is a carpenter and mines into wood. The former from the main shaft of their mine construct

several elliptical cells and line these with saliva which dries into a delicate membrane. The cell is then stored with pollen and honey, an egg laid, and the cell is sealed up.

One of our species of leaf-cutting bees (*Megachile argentata*) mines in the earth, unlike its near relations, but as it forms its cells of leaf-cuttings we have included it under the heading Upholsterers, with the other members of the genus.

Some of the solitary wasps share this habit of mining in order to make provision for their young. In these it is not a mass of pollen that is provided for the food of the future grub. Wasp-grubs require animal matter for their aliment, so the wasp has to hunt for caterpillars or spiders with which to stock the larder. Certain species restrict themselves entirely to spiders, others to grasshoppers, others again to caterpillars of a particular family of moths. The catching of caterpillars is a simple matter to a wasp, for its prey has no means of protecting itself; the grasshopper's activity and leaping powers give it a sporting chance; but the spider has to be approached warily, for its poison-fangs might put it upon equal terms with the wasp, were it not for the wings of the latter, which give it considerable advantage in manœuvring. However, the wasp has a due sense of the respect to be paid to those poison-fangs, the additional pair of legs, and the possibility of having strong cords wound round one; she, therefore, resorts to strategy when hunting spiders.

One of these spider-hunters is *Calicurgus*, but although it belongs to the group of burrowing Hymenoptera it mostly seeks for a ready-made hole in which to deposit its prey and its eggs. The Spider-wasp (*Pompilus*) is a true miner, but it reverses the order of operations followed by the solitary bees we have mentioned. Instead of first sinking a shaft and forming cells, and then seeking for provisions for the future grub, *Pompilus* first captures its spider and then excavates a hole in which to accommodate it. It is probable that this plan may frequently lead to the nest being ready first, owing to the first secured prey being carried off by another wasp whilst the mining operations are in progress.

Fabre gives a detailed account of some experiments he made in order to test *Pompilus*' sense of locality, and to ascertain how she would behave under certain conditions. A *Pompilus* that he had watched catch and sting a spider to render it helpless left her prey on a tuft of vegetation whilst she proceeded to make a burrow. She does not wait until the burrow is finished before looking for the spider, but leaves off work at intervals in order to visit the spider, to touch it and so assure herself that it is *her* spider, and that it is quite safe. In this case, as soon as the wasp had set to work on her mining operations, Fabre removed the spider to a distance of about eighteen inches. When *Pompilus* had worked for a spell she left off and flew straight to the spot where she had left her treasure, and exhibited grave

concern at its absence. She carefully walked over the surrounding ground as though to make sure that her memory was not at fault, then, satisfying herself that it was not there, she extended her survey and at length found her spider. But her actions showed that she was greatly astonished at the change of position, and she appeared to be unable to account for it. It was incomprehensible that she could have left a spider in that position; but seizing one of its legs she removed it to a tuft of vegetation, and resumed her digging. Fabre again removed it, and when the wasp next rested from her digging she flew straight to the place where she had last left it, and, failing to find it, quartered the immediate surroundings as she had done in the first place.

Five times the naturalist removed the spider, and every time *Pompilus* went through the same performance, seeking her treasure where she had last laid it, showing that her sense of locality was perfect. Had she been guided by scent she would probably have gone to one of the places where the spider had previously lain, but this she never did. Nor could sight have played anything more than a subordinate part in the discovery, for Fabre found that, though the spider was only a couple of inches from the wasp in some of her searches, she passed without seeing it. When, however, her sense of locality had brought her to the exact spot where she had left her prey, it was clear that the sense of vision came into play, for when Fabre placed the spider in a slight depression of the ground

and covered it with a leaf, the wasp could not find it.

Kirby and Spence have left us an account of the doings of a *Pompilus* which one of them saw hauling a spider to its shaft. "The attitude in which it carried its prey, namely, with its feet constantly upwards; its singular mode of walking, which was backwards, except for a foot or two when it went forwards, moving by jerks and making a sort of pause every few steps; and the astonishing agility with which, notwithstanding its heavy burden, it glided over or between the grass, weeds, and other numerous impediments in the rough path along which it passed—together formed a spectacle which we contemplated with admiration. The distance which we thus observed it to traverse was not less than twenty-seven feet; and great part of its journey had probably been performed before we saw it. Once or twice, when we first noticed it, it laid down the spider, and making a small circuit, returned and took it up again. But for the ensuing twenty or twenty-five feet it never stopped, but proceeded in a direct line to its burrow with the utmost speed. When opposite the hole, which was in a sand-bank by the wayside, it made a sharp turn, as evidently aware of being in the neighbourhood of its abode, but when advanced a little farther laid down its burthen and went to reconnoitre. At first it climbed up the bank, but as if discovering that this was not the direction, soon returned, and after another survey, perceiving

the hole, took up the spider and dragged it in after it."

All the species of *Pompilus* are not to be reckoned among miners, for some of them look about for a hole that has been mined by some other insect. They are all spider-hunters, and some of them secure their prey before they have prepared a nest. They take the precaution to sting their spider and then hang the helpless body in the forking of some plant until they have excavated their mine, which they do with such speed that the fine earth flies out of the hole like a fountain, so rapid are the movements of their limbs in digging. The Peckhams tried several experiments of substituting healthy spiders for those that had been stung, whilst *Pompilus* was digging her nest; but the attempt never succeeded—the wasp always knew that some trick had been played upon her, and always refused to be a party to the exchange. Even when a spider that had been stolen by them from one *Pompilus* was dropped near the mouth of another *Pompilus'* nest, her interest in it extended only as far as a tactile examination. She refused to accept it, though this would probably have saved her from a tedious hunt for a fresh specimen.

The mining of one of these—*Pompilus quinquenotatus*—has been described by these observers: "She was working away as furiously as though she had studied the poets and knew her *carpe diem* by heart. Faster and faster went the slender little legs; higher and higher rose the jet of dust above her.

Then suddenly there was a pause. The burrower had met with some obstacle. A moment more and she came backing out of the hole, her feet slipping on its crumbling edges. In her mandibles she carried a pebble, which was taken to a distance of four or five inches. Then, moving quickly, she swept away the dust that had accumulated near the mouth of the nest, re-entered the hole, and resumed the labour of excavation. We thought that the rate at which she worked was too violent to be kept up very long; and sure enough, before ten minutes had passed, the nest was deep enough for her purposes. . . . The wasp came out, circled round the spot three or four times, and then flew off like a hurricane. Never have we seen a creature so fiery, tempestuous, cyclonic. Before we knew her proper title we took to calling her the tornado wasp, and by that name we shall always think of her."

She was back in a minute with her spider, dug out a little more earth, then seizing her victim by one leg, she dragged it backward into the nest. "She remained hidden for about two minutes, then reappeared, and, seeming to be in as great a hurry as ever, filled the hole with dirt. To disguise the spot and render it indistinguishable from the rest of the field was her next care. Hither and thither she rushed, now bringing little pellets of earth and placing them above the nest, now sweeping away the loose dust which might suggest the presence of the *cache*, and now tugging frantically at a stone which she wanted to place over the

hidden treasure, but which was too deeply embedded in the earth to yield to her efforts. She did her work faithfully, although with such eager haste that all was completed at the end of twenty minutes from the time we saw her first. So well was the place hidden that it was only by careful orientation that we could be certain of its exact locality."

An allied insect, *Sphex*, has had its doings chronicled at length by Fabre. *Sphex* is a strenuous worker, for during the four weeks or so to which its activities as a winged insect are restricted it sinks no fewer than ten deep perpendicular shafts each with three or four separate chambers at the bottom, stored with food and each furnished with an egg. It selects a slight elevation of the soil, and into this it bores a horizontal gallery two or three inches in length. At the end of this gallery it sinks the perpendicular shaft, also for a depth of about three inches, and at the bottom the oval cells are made side by side. These are so constructed that the longer axes of the ovals are horizontal; and the first formed is provisioned and sealed up before the second one is dug.

The provisions for each cell consist of three or four field crickets, and these are carefully stung in the three principal nerve centres of the body, which has the effect of completely paralyzing the cricket without killing it. It is carried by the *Sphex* to the mouth of the burrow, where it is dropped whilst the wasp goes in to ascertain that all is right. Then, grasping the cricket by its antennæ,

the wasp, going backwards, draws its victim into the cell. A cricket so treated will remain alive, though utterly incapable of any movement, for three or four weeks, a much longer period than it takes the wasp-grub to consume it.

The cricket is laid on its back, and on one of the crickets in each cell a *Sphex* egg is deposited between the second and third pairs of legs. As soon as the egg is hatched, the young grub attacks the cricket at this point and burrows into its body, eating out all the interior in a week, and leaving nothing but the cricket's skin. The other crickets are similarly disposed of in turn, but, owing to the greater size of the wasp-grub, the pace is accelerated, so that in less than a fortnight from the hatching of the egg all the food is consumed. The grub then constructs an elaborate cocoon of two separate cases of white or yellowish silk, and within these a case of firmer texture and dark colour with a glossy surface. This is apparently formed of a mixture of fluid silk with the excrementitious matter that has been stored in the intestines all through the feeding period, and its purpose appears to be to protect the grub from damp during the nine months of its incarceration, prior to its assumption of the winged condition.

The Sand Wasps (*Ammophila*) have a similar predilection for the vertical shaft and the insect-stocked larders, only this time it is caterpillars that are used. The Ammophilas have the hind body connected to the fore body by a very long and

slender "pedicel." A well-known species is *Ammophila sabulosa*, which is entirely black save for a band of red which includes half the hind body and a third of the pedicel. There are many other species in different parts of the world, and their habits appear to be very similar, except that each species seems to have its own favourite caterpillar with which to provision its nest.

Sphex, during the time it is not excavating or hunting, occupies the vestibule afforded by the horizontal burrow, and passes the night there. *Ammophila* does not. When her work is over for the day, she literally "shuts up shop" by stopping the entrance with a small stone. In recent years we have had accounts of its operations from Fabre and Marchal, but as long ago as the summer of 1667 our countryman, John Ray, and his friend Willughby, were observing it, and Ray has told us in his *History of Insects* what they saw.

The Sand Wasp was dragging along a green caterpillar three times its own size. When it had dragged this load for a distance of about fifteen feet, it came to a hole previously dug in the sand, and left the caterpillar beside it whilst it set to work to remove a pellet of earth that blocked the mouth of the shaft. The wasp descended into the cavity, but soon reappeared and took the caterpillar again in tow. They both disappeared below, and the wasp came up alone after an interval and busied itself in rolling pieces of earth into the hole—"at intervals scratching the dust into it like a dog with its fore

feet, and entering as if to press down and consolidate the mass, flying once or twice to an adjoining fir-tree, possibly to procure resin for agglutinating the whole. Having filled the burrow to the level of the surrounding earth so as to conceal the entrance, it took two fir-leaves lying at hand, and placed them near the orifice, as if to mark the place."

Mr. and Mrs. Peckham have given us most interesting accounts of two American species of *Ammophila*—*A. urnalis* and *A. gracilis*—agreeing in the main with Fabre's observations of *A. hirsuta* and *A. sabulosa*, but, of course, with variations which mark the specific difference of the insects. One individual *urnalis* whose behaviour they watched was so precise in all she did that we cannot refrain from quoting part of their account:

"We remember her as the most fastidious and perfect little worker of the whole season, so nice was she in her adaptation of means to ends, so busy and contented in her labour of love, and so pretty in her pride over the completed work. In filling up her nest she put her head down into it and bit away the loose earth from the sides, letting it fall to the bottom of the burrow, and then, after a quantity had accumulated, jammed it down with her head. Earth was then brought from the outside and pressed in, and then more was bitten from the sides. When, at last, the filling was level with the ground, she brought a quantity of fine grains of dirt to the spot, and picking up a small pebble in her mandibles, used it as a hammer in

pounding them down with rapid strokes, thus making this spot as hard and firm as the surrounding surface. Before we could recover from our astonishment at this performance she had dropped her stone and was bringing more earth. We then threw ourselves down on the ground that not a motion might be lost, and in a moment we saw her pick up the pebble and again pound the earth into place with it, hammering now here and now there until all was level. Once more the whole process was repeated, and then the little creature, all unconscious of the commotion that she had aroused in our minds—unconscious, indeed, of our very existence and intent only on doing her work and doing it well—gave one final, comprehensive glance around and flew away."

Dr. S. W. Williston records a somewhat similar experience with *Ammophila yarrowii*.

There is only a single cell at the bottom of the Sand Wasp's shaft, and some species fill this with several small or medium-size caterpillars; others with a single large caterpillar. All of these, of course, are stung in order to paralyze them. Fabre says of *Ammophila hirsuta*, that she provisions her cell with only one caterpillar, that of one of the Noctuids, which is an underground feeder and, therefore, cannot be found by sight. This caterpillar she stings about nine times in as many forward divisions of its body. She waits until she has secured this caterpillar before she sets to work at her mining operations.

Another genus of these "fossorial wasps" is *Tachytes*, which resembles *Sphex* in its habits. It sinks vertical shafts in the ground, and uses insects of the order Orthoptera for the stocking of its pantries. Some species take field crickets, some grasshoppers, others mole crickets; and one has the courage and skill to use the murderous mantis, whose scissor-like fore legs could easily cut *Tachytes* into little bits. But *Tachytes* appears to know its risk and relies on strategy: it flies around the mantis for a time, just out of reach, and the rapid turning of the latter's head to enable it to keep at least one eye on *Tachytes* produces confusion in its nerve-centres. Then is *Tachytes'* chance: it swoops down and thrusts its sting between the bases of the formidable fore legs, paralyzing the nerves that operate them. The other legs are served in like fashion, and the mantis is at once in a condition to be hauled off to *Tachytes'* larder.

In another genus of small mining wasps—*Astata*—a strange taste is exhibited—judged from the human standpoint we should have to call it a depraved taste. These wasps for the sustenance of their progeny select two of the most repulsive of insects—one, a plant-bug (*Pentatoma*), the other a small cockroach. Nearly all the bugs are provided with stink-glands which emit the most disgusting odour, and *Pentatoma* is not one of the exceptional kinds. Some people say, however, that the smell given off by the cockroach is even worse

than that of bugs. The burrow of *Astata* ends in a single cell.

The whole of these mining wasps that we have mentioned so far agree in the fact that they lay up provisions for a progeny they will never see, and having sealed up the cells or the burrows they manifest no further concern in them. In the genus *Bembex*, however, we find an advance upon this condition of things, and an approach to the care with which the social wasps feed the grubs of the community continuously, or at least as frequently as they require food. *Bembex* is not represented among the wasps of Britain, but one species—*Bembex rostrata*—is found in Southern Europe, and Fabre has made it the subject of one of his remarkable insect biographies, which should be read in full by all interested in wasp life. Only the merest summary can be given here, in the hope that the full account will afterwards be sought by our readers.

The wasp drives her burrows in fine loose sand and makes no effort to give them permanence by cementing the walls. Instead of provisioning her cells with sufficient food to last the grub until it reaches its full size, she merely catches a two-winged fly, which she does not paralyze, but kills, and depositing it in the burrow, lays an egg upon it. Her excavating work is done entirely by means of the fore legs, which work with such rapidity that the loose sand pours out in a stream from beneath her. When the dead fly is placed in this burrow

the sand is drawn over it until there is no sign of its situation, and the marvel is that the wasp can ever find the place again. But she does, for her egg hatches next day, and the fly is only sufficient to feed the grub for two or three days. By that time *Bembex* is back with another fly, and rapidly excavates straight to her offspring, where she leaves the new supply of food. Fabre says that she makes several burrows in succession, and therefore has to keep them all supplied with fresh viands. This implies knowledge of their several whereabouts (all in the immediate neighbourhood) and of when their supplies will require replenishing.

The flies chiefly patronized by *Bembex* for this purpose are gadflies (*Tabanus*). Cattle raisers should, therefore, regard *Bembex* as a good friend. As far away as the Americas, North and South, the Bembecid Wasps—some of them far superior in size to the European species—show this same preference for blood-sucking flies, and they have often been observed to capture them in the very act of drawing blood from horses. Bates relates that when on the Amazons one of these flies—a *Motuca*—had settled on his neck for a feast when a *Bembex* as big as a hornet swooped down and captured his tormentor.

Bates describes the mining operations of a small pale-green species of *Bembex* (*B. ciliata*) which he found plentiful near the bay of Mapirí, near Santarem. He says: "When they are at work, a number of little jets of sand are seen shooting over the surface of the sloping bank. The little

miners excavate with their fore feet, which are strongly built and furnished with a fringe of stiff bristles; they work with wonderful rapidity, and the sand thrown out beneath their bodies issues in continuous streams. They are solitary wasps, each female working on her own account. After making a gallery two or three inches in length, in a slanting direction from the surface, the owner backs out and takes a few turns round the orifice apparently to see if it is well made, but in reality, I believe, to take note of the locality, that she may find it again. This done, the busy workwoman flies away; but returns, after an absence varying in different cases from a few minutes to an hour or more, with a fly in her grasp, with which she re-enters her mine. On again emerging, the entrance is carefully closed with sand. During this interval she has laid an egg on the body of the fly, which she had previously benumbed with her sting, and which is to serve as food for the soft, footless grub soon to be hatched from the egg. From what I could make out, the *Bembex* makes a fresh excavation for every egg to be deposited; at least, in two or three of the galleries which I opened there was only one fly enclosed."

Although a solitary wasp, *Bembex*, like *Philanthus* and *Sphex*, likes to have neighbours, and so we find a number of them occupying a small plot of ground, but each "pegging out her own claim" in that restricted mining region. Yet, though they appear to like neighbours, they are not what could

be called neighbourly in their behaviour. If one comes home with an extra fine fly, two or three of her neighbours are likely to try to hustle her with the object of getting possession of her treasure. They all leave off digging and start off hunting at the same time, but they evidently do not all occupy their absence in the same way, for about half the colony come back empty-handed and try to rob those that are laden. They even fight without any apparent *casus bellum.*

To feed its grub with a succession of flies until it has reached the stage when it spins a cocoon and pupates, is a serious responsibility for the mother *Bembex.* When Fabre took a partly grown larva from its cell there was evidence in the remains that it had already consumed twenty flies, and he gave it an additional sixty-two as requisite before it ceased feeding. It consumed an average of slightly over ten flies a day. The Peckhams got similar results from their feeding experiments.

The *Bembex* grub having finished its feeding prepares for its long period of inactivity prior to its issue as a perfect wasp by constructing a strong cocoon. Its silk-glands do not appear to afford sufficient material for the purpose, but what it has it uses to the best advantage as a cement with which it agglutinates grains of sand, and so elaborates a solid structure well fitted to protect its tender body among the shifting sands, and to keep it dry.

A North American mining wasp, known as *Sphecius speciosus*, has been described by Riley as

provisioning its cell with a cicada, an insect twice its own weight. In the vicinity of moisture the cicada rapidly becomes mouldy, so the wasp has to make her burrow in dry earth. Her method of getting her prey from the place of its capture is ingenious: she hauls it up a tree until she has reached a height sufficient to allow of her flight with it on a descending plane, flying up from the ground with such a load being a very difficult matter. The feeding period of the grub only extends to about a week, then it forms a cocoon in which much earth is held together by its silky secretion.

One of the commonest of the British burrowing wasps is *Mellinus arvensis*, a pretty black-and-yellow-banded creature only half an inch in the length of its body. It provides for its offspring by supplying its burrows with two-winged flies. To catch these it resorts to strategy. Certain species of flies abound upon cow-droppings, upon which they feed, and the congregation of yellow-brown flies offers a fine opportunity for those insects that prey upon them. But the flies are very alert, and fly off with rapidity. *Mellinus*, instead of at once opening attack, joins the throng as though actuated by similar tastes, and appears to have no other design than to share their repast. No resentment of her intrusion is shown, for there is enough for all. But no sooner does she get close enough to a fly to make her purpose sure, than she pounces upon it, and carries it off to her burrow.

Smith says that *Mellinus* may at times be seen apparently dead upon the cow-dung, but if you watch her until a fly comes within reach she will come to life at once and secure her unsuspecting prey.

Another gathering-place for flies is on the flat clusters of umbelliferous flowers, such as wild carrot, where they are busy licking up nectar and eating pollen. *Mellinus sabulosus* takes advantage of such resorts to get all the flies she wants for her burrows. Capturing a fly, she stings it, and lays it down before the mouth of her burrow whilst she turns round in order to enter the burrow backwards with her prey. By taking advantage of the opportunity thus afforded, Lucas secured stung specimens of the flies, and found that they remained alive, though powerless, for about six weeks.

In the genus *Cerceris* the species exhibit a most remarkable sense of the relationships of the insects captured for the food of their young—a sense that the classifying entomologist might envy. They do not always restrict their selection to insects of one species, as bees are said to restrict their honey-gathering to one species of plant; in such a restriction they might be guided solely by form and colour, but they gather species indifferently so long as these are members of the same natural family.

Thus, our own *Cerceris arenaria* confines its operations to beetles of the weevil family—a vast family whose species differ greatly in size and colouring. She is not guided in her selection by either of these things, though the colour sense in

wasps is known to be very acute; but every beetle selected is bound to be a weevil. It is probable that, to the keen olfactory sense of the wasp, each beetle family has a peculiar clan smell. *Cerceris labiata* restricts her attentions to one particular species of beetle, a relation of the so-called turnip-flea. See how in these matters a knowledge of entomology would help the farmer and gardener, by enabling them to encourage insects that help them to keep down the numbers of others that are noxious. The species of *Cerceris* are regarded by gardeners as *young* specimens of the ordinary wasp, and as such destroyed whenever opportunity offers, whilst weevils and turnip-fleas increase and inflict real injury upon garden produce. The whole of these fossorial Hymenoptera, as a matter of economics, ought to be religiously protected by all interested in husbandry; for those that are bees are useful in flower pollination, and the wasps destroy large numbers of plant-eating insects. Some species intimately studied by the Peckhams in North America have yielded most interesting results.

"They might be considered the aristocrats in the work of wasps, their habits of reposeful meditation and their calm, unhurried ways being far removed from the nervous manners of the Pompilidæ, or the noisy, tumultuous life of *Bembex*. Their intelligence is shown by their reluctance to betray their nests, and by their uneasiness at any slight change in the objects that surround them. It is not necessary to attempt to catch them or to

make threatening gestures in order to arouse their sense of danger. If you are sitting quietly by a nest when a wasp opens her door in the morning she will notice you at once, and will probably drop out of sight as though she resented your intrusion into her privacy. After a little she will come up again and will learn to tolerate you, but at the least movement on your part, almost at the winking of an eyelid, she will disappear."

They all dig deep, tortuous burrows from which one or more cells branch off, and these they stock with insects. These cells are made and provisioned in turn; and as soon as one is filled with food, and an egg laid, it is closed up. When they quit the nests for business or pleasure they leave the entrance open, but as soon as they return they close it after them by bringing up earth from below. When they are away it is probable that access to the cells is barred, otherwise they would be too accessible to parasitic enemies. "The closing [of the outer entrance] is sometimes effected by pushing the earth up backwards with the end of the abdomen; but the hole is rather too large for this method, and more frequently the wasp comes up head first, carrying a load of earth in her front legs. This is placed just within and to one side of the entrance, and then more armfuls are brought up, until, after two or three trips, the opening is entirely filled."

Like *Cerceris*, the wasps of the genus *Philanthus*, with their black and yellow bands, may easily be

mistaken for ordinary wasps. They provision their cells with bees, *Andrena*, *Halictus*, and even the Honey Bee. A Continental species is so much addicted to onslaughts upon the Honey Bee (*Apis mellifica*) that it is named *Philanthus apivorus*. Our own species, *P. triangulum*, is not free from this reproach, but bee-masters, who appear to be capable of knowing only one insect well, regard it as the Common Wasp (*Vespa vulgaris*), and will tell you harrowing tales of the way in which the latter decimates the hive population. The bee is stung and its body kneaded in order to set free the honey it contains. Upon this the wasp feeds, and entombs the remains in its cell for the nourishing of its grub. Owing to this habit of *Philanthus*, which causes the death of the bee, it cannot store its cells with sufficient food to last the grub, but has, like *Bembex*, to take in fresh supplies at intervals.

According to Fabre the burrows of *P. apivorus* are about three feet in depth—an astonishing piece of mining to be carried out, unaided, by a wasp that is only half an inch long. *Philanthus punctatus*, an American species, was found by the Peckhams to run into a bank to a length of twenty-two inches, fourteen of which ran parallel to the surface at a depth of eight inches. " We have no doubt that *punctatus* completely provisions one pocket and closes the opening from it into the gallery before she starts another, making a series of six or eight independent cells. The provision for one larva is probably twelve or fourteen bees, the

capture of which, in good weather, would be a fair day's work." The stinging of the bees was the beginning and end of the operation; they did not find that this species kneaded her captures in order to obtain honey from them, nor indeed was there any attempt to remove it. These wasps have the habit of sitting in the mouth of their tunnels, with the face filling it, looking out upon the world for some time before starting out in the morning, appearing as though considering the work that lay before them and the best way of accomplishing it.

Aphilanthops frigidus digs a shaft eighteen inches deep, and stores her cells with ants, which she stings and strips of their wings. The shaft has a cup-shaped opening. In trying to explore one of these nests in loose soil, the Peckhams had difficulty in ascertaining the direction, so they hit upon the expedient of borrowing an ant that *Aphilanthops* had dropped in the doorway whilst she went in and turned round, and they tied a thread to it to serve as a guide-line. But the wasp was not inclined to aid them. She pulled in the ant and took it part of the way down with the thread attached; but before any great length of the guide-line had been paid out the "thread was seemingly bitten off, as we found the free end without the ant. A second attempt brought no better results."

Fabre rather insists upon the remarkable actions of these hymenopterous insects as due to instinct. They do these things because they cannot help it, and some of his experiments support this view;

others, however, point in another direction, and the Peckhams found that instead of doing things automatically and uniformly there was a great amount of variation in the way things were done by the individuals of any one species. The moving of a plant near the covered-up nest would disarrange the wasp's ideas as to locality and set her hunting around instead of going straight to it.

Some Fossores do not mine in the ground, but in wood, as in the more or less decayed wood of tree-stumps and posts, or the more pith-like centres of bramble-stems and the stalks of herbs. It seems, therefore, more appropriate to deal with these under the head of Carpenters, or workers in wood. To that section of this work we will relegate them, whilst we consider a few miners among the beetles.

The pre-eminent mining beetle is the Sacred Scarab (*Scarabæus sacer*), whose industry attracted the attentions of the ancients, who saw in the movements of its rolling ball of food an emblem of terrestrial and planetary revolutions and of other matters with which this work is not concerned. For a great number of years stories have been told in natural-history books which were believed to embody the facts of the Scarab's economy, but that terrible M. Fabre, who by his patient observation has set us right upon so many points of insect behaviour, declares almost all the supposed facts to be as erroneous as the ideas of the ancients. The careful rolling of the sphere of dung and its subsequent burial is true enough, but it does not contain

the egg it was supposed to. It is gathered not to feed the beetle's grub, but the grub's parent.

The Scarab is wonderfully equipped for the work it has to do as one of nature's sanitary officers. Its head is developed forwards as a semicircular plate whose free edge is cut up into six tooth-like points, and its front pair of legs are without feet (*tarsi*), but the next joint (*tibia*) is very large and stout and its edges bear very bold teeth. The hindmost pair of legs are long, and so curved that they constitute an efficient pair of callipers. With its shovel head and its fore legs the Scarab scoops up and kneads a mass of cattle dung, which is fashioned into a ball with the aid of the calliper hind legs. This is kept on the roll whilst additions are made to its exterior until it is of large size—sometimes equal to a man's closed fist—and of perfect rotundity. The Scarab pushes it backwards, holding it with the hind legs, until it arrives at what is considered a suitable spot of ground. The beetle then sets to work scraping with its fore legs and shovelling the earth with its head until it has sunk a pit large enough to bury its big ball. It then gets into the pit besides its pudding and commences to feed upon it.

One would imagine, from the relative sizes of beetle and ball, that more than half would be left unconsumed; but the Scarab sticks to the task, feeding without any rest or other intermission until the last scrap is eaten. Then the gourmand climbs out of the hole, and flies off to where the cattle

have provided a further supply of food. Here another big ball is rolled up, and the same process is gone through again. This happens in the spring and early summer. During the hottest part of summer the Scarab remains in the earth after one of these Gargantuan feasts, and enjoys a period of repose until the autumn brings cooler and moister days. Then the Scarab arouses and ventures into the world again.

At this season the female Scarab appears to realize that she has a duty to perform in the interests of her race. A bigger excavation is made in the earth, and when it is completed a great quantity of dung is rolled into it, and graded. The coarsest material is so arranged that the grub for whose food it is intended will not reach this portion until its digestive powers are well developed. It will reach and eat a finer grade before that time; but for its newly formed jaws and delicate stomach the mother Scarab prepares a special layer by partially digesting some of the food herself. In this portion the egg is laid, so that when it hatches, the young grub makes its first meal of this specially prepared food. When the food is all gone the grub is fully grown, and changes into a chrysalis, and in spring issues from its cell as a perfect Scarab.

The sub-family Coprides, to which the Scarabs belong, includes about five thousand species of beetles, and most of these have similar habits of burying dung for the sustenance of their grubs. The well-known Tumble-dung Beetle (*Ateuchus*

pilularia) of North America rolls its balls of dung along to the shaft it has prepared for their reception, where it deposits its eggs. These shafts are declared by Catesby to be about three feet in depth.

Our own Watchman, Clock or Dor Beetle (*Geotrupes stercorarius*), whose blundering, noisy flight is so noticeable on summer evenings as to have gained for it a true folk-name—a very unusual thing for beetles to attain to—is also among the miners. Having, by its acute sense of smell, received intelligence of a fresh deposit of dung, she flies on strong wings straight to the spot, and burrows into the mass. She does not stop at the manure, but digs straight into the earth below, forming a perpendicular shaft about a foot deep. Her fore legs are well adapted for this work, for though they are provided with weak feet, the tibia, like those of the Scarab, are strong and toothed along the edge used for burrowing. They are useful also for scraping together the dung which she drops down the shaft, afterwards laying an egg upon it. The grub which hatches out of the egg feeds upon this store.

It has long been a subject for admiring wonder that an insect that deals with clinging filth should contrive, as the Watchman does, to keep its polished armour so clean and bright. It is equally remarkable that the hosts of soft-bodied mites that crowd upon the underside of this and other species of dung beetle manage to escape destruction and retain their hold during these burrowing operations. The smaller Lunar Dung Beetle (*Geotrupes typhœus*)

excavates deep burrows on heaths and carries down rabbit and sheep dung to feed upon.

The smaller beetles of the genus *Aphodius* share with *Geotrupes* the habit of sinking shafts and burying dung for the benefit of their future progeny. We have seen these beetles to the number of hundreds swarming on a patch of cow dung, and on returning that way a few hours later found scarcely a beetle, but the patch closely riddled with perforations corresponding with as many shafts beneath, in which the beetles were no doubt very busy.

Many other beetles may be considered as miners from the fact that they spend part of the day underground; but as a rule they take advantage of crevices already existing. There are some, however, that make definite burrows for themselves. As an example of these mention may be made of the Cockchafer or May-bug (*Melolontha vulgaris*) which, after spending about three years underground as grub and chrysalis, and enjoying a brief spell as a creature of the air, during which time she inflicts serious damage on the foliage of trees, at length enters the ground again to deposit her eggs.

She sinks a shaft to a depth of six or eight inches, not going below the layer of vegetable mould in which the roots of plants run. At the bottom of the burrow she lays a batch of oval yellow eggs to the number of thirty or forty. These hatch in about a month, and at first the grubs feed upon the decaying vegetable matter they find around,

PLATE 6 MINERS. Page 54

The beetles above are the Lunar Dung beetle and the green Tiger beetle, both miners in the earth. Below, the light zig-zag marks on the bramble leaf show the tracks of caterpillars of a small moth (*Nepticula*) that mine between the upper and lower skins.

Photos by Author.

PLATE 7 NESTS OF A MASON-WASP Page 76

This cluster of cells attached to a plant stem are built up of mud in which small stones are embedded. They are each stored with about sixteen small caterpillars and a single egg of the mason. Magnified four times.

Photo by Author

but when they grow a little bigger and stronger they devote their energies to the destruction of roots of grass and other plants. For three years they continue to feed, and then, being full-grown, they burrow to a depth of about three feet from the surface and change to the chrysalis condition. The grubs are whitish, clumsy-looking creatures, their hinder parts being so swollen that they have to lie on their sides whilst they feed.

The Tiger Beetles (*Cicindela*), of which one species (*C. campestris*) is among the most brilliant of our beetles as it flies in the sunshine, are miners in the grub state. The female beetle is provided with a strong ovipositor with which she bores into the ground and deposits her eggs. The grub, which is more active than the larvæ of many beetles, digs a straight vertical shaft and enlarges it to fit as he grows. His head and the adjoining part of his body are broad and flat, forming a sort of shovel with which he carries up the excavated soil and deposits it around the mouth of his deep burrow.

In addition to his six legs he has a couple of hooks on his back which help him materially in climbing to the mouth of his tube and in supporting him whilst there. This is an important point, for he spends much time in this position, his flat head acting as a stopper to the shaft. Here he waits until some unlucky insect walks across. Then the head is jerked back suddenly and returned with the jaws open. The insect is seized and taken to the

bottom of the shaft, where its juices are sucked and the innutritive remains hoisted out.

The last of these earth-miners to whom reference will be made are the Mole Cricket (*Gryllotalpa vulgaris*) and the Field Cricket (*Gryllus campestris*). The Mole (*Talpa europea*) is a wonderful example amongst mammals of adaptation of structure to mode of life; and it is rather startling to find among insects so close a copy of one of the higher animals as we do find in the Mole Cricket. There is the same cylindrical form of body, and the same peculiar spade-like development of the fore limbs to render them serviceable as most efficient burrowing tools. The name of the creature is obviously the right one; our forefathers who bestowed it could have had no difficulty in the matter. One would imagine that the name would suggest itself to any one who had seen a mole. Yet we were surprised to learn quite recently that a closely allied species to our European Mole Cricket is known to British planters on the Indian tea-gardens as the Mouse Insect. To these planters the fore legs suggested the feet of a rodent.

The Mole Cricket makes horizontal runs much after the fashion of those of the mole, but nearer the surface. The mole's burrows are to enable it to have a large extent of hunting-ground where he can come across worms and insects such as the grub of the cockchafer lately referred to. The Mole Cricket is supposed by the gardener to have roots chiefly in view, though insects form part of

his menu, as they do for the House Cricket, which has the reputation of being a deadly enemy to the cockroach. Anyhow, in the South of England, where they occur, Mole Crickets have a bad reputation with gardeners for the havoc they make among cultivated plants.

Kirby and Spence describe it as "a terrible devastator of the produce of the kitchen garden. It burrows underground, and devouring the roots of plants thus occasions them to wither, and even gets into hot-beds. It does so much mischief in Germany that the author of an old book on gardening, after giving a figure of it, exclaims, 'Happy are the places where this pest is unknown!'" We have good reason to believe that these eminent authorities were wrong, and that far more good is done by its destruction of insects than the harm it does by cutting roots.

The female Mole Cricket, in addition to her food-finding burrows, constructs a vertical shaft, and a little to the side of the bottom of it she hollows out an oval cell with smooth and even polished walls. In this cell she lays her eggs, to the number of several hundreds, and is said to watch over the young crickets until they have shed their first skins, after which they separate and each digs a burrow for itself.

The Field Cricket (*Gryllus campestris*), which much more nearly resembles the House Cricket, also burrows, but not so extensively. Its burrows are more for the purpose of retreat than for hunting,

and as its fore legs are not modified for digging like those of the Mole Cricket, it is compelled to do its tunnelling with its jaws.

There is another group of Miners to whom reference should be made, although they mine not in the earth, but in vegetable substances. One portion of these we have dealt with in a later chapter as Carpenters, but there are others known as Leaf-miners, who spend their larval existence in making tortuous burrows in the soft cellular tissue (*parenchyma*) of green leaves. The larvæ that get a living by this industry are not confined to one natural order; in their perfect state they are moths, flies, and beetles. They can hardly be classed among insect pests, for as a rule they do not destroy a whole leaf, but they cause a good deal of annoyance to some gardeners who are vexed to see even one disfigured leaf on a plant. An exception to this remark should be made in the case of the Celery Fly, whose larva eats so much of the leaf as to seriously affect the storing up of the material that goes to the formation of the firm white base of the leaf-stalks for which the plant is cultivated. Where such depredations do not have serious effect the leaves are those of trees or shrubs.

The moths whose larvæ mine leaves are the most numerous, and when it is stated that in Britain alone we have somewhere about three hundred and fifty species of these lepidopterous leaf-miners, it will be seen that it is impossible in this place to do more than mention a few sample species. These

are all very small moths—they include the smallest known moth—of the kind that should one by mischance get into the house, is pounced upon as "one of those horrid clothes moths," though all leaf-miners are perfectly innocent of the crimes perpetrated by clothes moths.

The mines of some of these larvæ must be familiar to all who take any notice of natural objects in the country. Every garden that contains a few rose-bushes will furnish examples ready to hand, and outside it the first bramble-bush will show us some fine examples of mined leaves. The effect of the little miners' industry is to clear out the cellular matter between the upper and lower skins of the leaf. The miner works rather erratically and follows a serpentine course, perhaps roughly following the margins of the leaf, sometimes doubling upon itself and even crossing an earlier route. As one looks at a leaf where the miner has finished, or all but finished his work, it is possible to follow his course by observing that as he increases in size the mine becomes broader.

Mr. Alfred Sich, F.E.S., who has made a special study of these minute moths, has given us from his own observations a sketch of the life-history of De Geer's Leaf-miner (*Nepticula anomelella*), which he says scarcely differs from that published by De Geer in 1752. This is the species whose mines are commonly seen upon the leaflets of the rose. The moth glues her almost colourless egg to the underside of the leaf, and the young caterpillar bores

through the egg-shell straight into the substance of the leaf without seeing the direct light of day. Making its way from the lower to the upper cuticle of the leaf, it begins its mine just under the cuticle. It is then less than one twenty-fifth of an inch long, and has no limbs. Its progress through the leaf-material as it feeds appears to be accomplished by the alternate contraction and expansion of the swollen first three segments of its body.

When full-grown the caterpillar has attained to the length of one-fifth of an inch, and it has lost its appetite. Not wishing to finish its career in the interior of the leaf, it cuts a half-circular slit in the cuticle, and crawls out. It then proceeds to spin a little cocoon around itself, probably in the angle at the base of a spine on the rose-stem, where it changes to a chrysalis, and a few weeks later issues as a delicate little moth.

Other species of the genus *Nepticula* may be found mining the leaves of oak (*N. atricapitella*), elm (*N. viscerella* and *N. marginicolella*), beech (*N. tityrella*), birch (*N. luteella* and *N. betulicolella*), hawthorn (*N. oxyacanthella*, *N. perpygmæella*, *N. ignobilella*, and *N. atricolella*), bramble (*N. splendidissimella*), hazel (*N. floslactella* and *N. microtheriella*), and many other plants.

The Laburnum Miner (*Cemiostoma laburnella*) proceeds somewhat differently. " After leaving the egg, the caterpillar makes a reddish-brown circular dot, about one twenty-fifth of an inch in diameter ; when this is complete it changes its first skin and

then mines out a very fine gallery, leading away from the blotch, and about one-sixth of an inch long. At the end of the gallery it changes [its skin] a second time, after which it mines out another circular blotch about one-quarter of an inch in diameter, which has a black appearance. When this is complete it makes a pale ring round the blotch; in this it changes once more, and then commences the last part of the mine. The last portion forms a large irregular blotch, which occupies most of one half of a laburnum leaflet, and is marked with many curved dark lines. . . . When fully grown it comes out of the mine to spin its cocoon. . . . Having found the right situation, it builds a wall of silken strands on each side of itself, and then between the two walls it spins a shuttle-shaped cocoon in which it turns to a pupa. When mature there emerges a beautiful white moth with black and yellow rays at the tip of the wings. An almost similar moth feeds on the common broom, the leaves of which are very small and not very numerous. But this species, *Cemiostoma spartifoliella*, does not trouble about the leaves, but lives beneath the bark of the twigs, where it makes long serpentine galleries in which it lives throughout the winter. When the warm days of May come it leaves its winter retreat and spins its white cocoon on broom stems. In a warm evening in July the moths may be seen flying in swarms around the bushes" (Sich).

Other genera besides the genus *Nepticula* share

this mining habit, and it is easy to find examples on all kinds of plants. It is not even necessary to search for them, for the mines in most cases advertise the presence of the miner. This, however, is not the case with one of the most plentiful of all, and one of the most remarkable. We may own a poplar-tree nearly all of whose leaves are tenanted by the caterpillars of *Phyllocnistis suffusella*, and never suspect the fact. We may see the evidence of their presence, but imagine that a snail or slug had been crawling over all the leaves, leaving a slightly shining track. These tracks are really those of the caterpillar under the upper skin. This larva differs from most of the miners in the fact that he takes no solid food. Strictly speaking, it is perhaps not right to include him among the miners, for all he does is to sever the connection of the upper cuticle and the parenchyma, and instead of eating his way through the latter, he is content to suck up the sap that flows from the severed cells. Upon this liquid fare he subsists entirely.

When it changes its skin the second time its form is entirely altered, for it develops a bi-lobed tail which gives it a fish-like appearance. At the end of this stadium, as it is termed, the caterpillar has reached the edge of the leaf, where it stretches itself out and appears to die; but it is only another change. About a day later it has cast its skin again, and now appears in more normal caterpillar form, and white, whereas before it was colourless. It feeds no more, but has assumed its new dress

for the purpose of spinning its cocoon and changing to a chrysalis. In spinning the cocoon the edge of the leaf is folded down to conceal it, and as you bend this back to reveal the chrysalis you rupture the delicate cuticle, and may imagine, as we long imagined, that the chrysalis is outside the cuticle. After a few days it emerges from the chrysalis as a beautiful little white-and-grey moth.

Respecting the frequency of these lepidopterous leaf-miners, the following paragraph from Sich may be suggestive and helpful to those readers who would like to get a little first-hand knowledge of these insects. "Our indigenous trees which usually grow in numbers together afford food to numerous species of leaf-miners. For instance, the oak offers a home to at least twenty-four species, while the birch harbours not fewer than thirty-one. But the crab-apple, the maple, and the buckthorn also have leaf-miners attached to them. There are two species which we might even call needle-miners because they mine in the needles of the Scots pine. Bramble-bushes, honeysuckle, and convolvulus have their leaf-miners, and even mistletoe is not exempt. Many low herbs, such as the clovers and sorrels, give shelter to Leaf-miners, and when we come to the grasses and sedges we find at least forty species which obtain their nourishment from these elegant plants."

A few Leaf-miners may be found among the larvæ of beetles, and there are at least two well-known examples among the grubs of two-winged

flies. One of these is the Celery Fly (*Trypeta onopordines*), which also attacks the leaves of the parsnip. Probably it would not seriously affect the plant were its mines restricted to the developed leaves of mature plants, but it attacks the tender leaves of the seedlings and makes them sickly or kills them right out.

Another fly with leaf-mining grubs is the Holly-leaf Fly (*Phytomyza ilicis*). Holly-trees are often seen to have scarcely a leaf that has not one yellow blotch upon it, and often there are several blotches on one leaf, testifying to the work of as many miners. The mines are rarely serpentine, but mostly shapeless patches, the grub turning about and eating the parenchyma as far as he can reach on all sides without moving his hind body. The eggs are laid in summer, and the grubs go on feeding right through the autumn and pass the winter in the pupa condition, issuing as small black flies at the beginning of summer.

Even the larva of one of the Sawflies is found among the Miners. This is the Raspberry-leaf Miner (*Fenusa pumila*), a minute four-winged fly with black body and black-and-yellow legs. The grubs feed upon the parenchyma in approved miner fashion, and are sometimes in sufficient numbers to cause alarm to the small-fruit grower. His remedy is to go over the bushes and press the mined leaves between finger and thumb, and the mining work is stopped.

III

MASONS

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III

MASONS

THOUGH the Masons are not so numerous as the Miners, the insect world includes some artizans who are very efficient in the use of trowel and mortar, and some of them work with such fine regard for form that they may be regarded even as art potters. It is among the Hymenoptera, the order that includes the most intelligent of the insect tribes, that we find the art of the mason developed. Some of them are known as Mason Wasps and Mason Bees, others as Mud-daubers, owing to their preferring solidity to elegance in their structures.

Bates found in the Valley of the Amazons a number of small bees of the genus *Melipona* which store honey and gather pollen, much as the larger Honey Bee does. But the workers of certain species of the *Melipona* also gather clay with which, whether they build in a hollow tree-trunk or in a bank of earth, they completely surround the nest with a solid wall.

In the South of Europe there are several Mason Bees of the genus *Chalicodoma*, the best-known being

C. muraria. Réaumur told its story many years ago, and more recently Fabre has paid much attention to it, making experiments that help to an understanding of the order of its intelligence.

Réaumur says that having decided upon the site of her nursery, the bee carefully selects sand, grain by grain, for her building materials. These she glues together by means of a viscid secretion from her mouth, until they form masses the size of small shot, and transports them in her jaws to the building site. With a number of these, cemented by the same means, she constructs her foundations. Upon these she runs up the walls of a thimble-shaped cell, an inch long and half that in breadth. Before it is roofed in she becomes a gatherer of pollen and honey with which she stocks the cell, and lays an egg in with it. She first puts her head into the cell, on her return from one of these journeys, and discharges her gathering of honey. The pollen has been collected on the hairs of her lower surface, and to discharge this she gets into the cell backwards and cleans the pollen off in such manner that it falls to the bottom. When the requisite quantity of each has been stored she gets her head well into the cell and with her jaws works up the honey and pollen into a homogeneous paste; then lays her egg and seals up the top of the cell.

The construction of one cell takes the labour of two days. Eight or nine cells are built one against the other in this way, and then the whole of them

are coated by a general mass of masonry. When finished the dome-shaped structure is the size of half an orange. The outer coating of all is composed of grains of sand coarser than those previously used. It harmonizes well with the natural stone to which it is attached, or on a close examination might be supposed to be a daub of mud. But it sets so hard that it is with difficulty explored with a knife-blade.

This building work is carried out in spring, and the solidity of the entire structure has evident relation to the fact that in an exposed position it has to protect the inmates from being dried up by summer heat and from being frozen by winter's cold, for it is not until the following spring that the young bees emerge. Then the hardness of the masonry presents no difficulty to them: their jaws are stout enough and sharp enough to pick it to pieces and clear a way large enough to permit their exit. Yet Fabre found that their powers in this respect were somewhat limited. If the nests were closely surrounded by paper they cut through it as though it were part of their natural enclosure; but if the paper wall was so arranged that it left a clear space between it and the nest, they cut through the latter, of course, but did not know how to deal with the paper as a separate obstacle, and perished in this outer prison. The difference is probably due, as suggested by Pérez, to the fact that in the larger space they do not know where to begin, whilst in the confined space of the cell

they are bound to concentrate their efforts upon one spot.

By marking some of these bees with paint and taking them away to a distance of four kilometres (that is, over a quarter of a mile) before releasing them, Fabre found that their homing instinct was so good that they were back working on their unfinished nests next morning. But though their sense of locality was thus proved to be very good, he found that when he transposed neighbouring nests they were unable to distinguish their own property, for a bee set to work at the nest which now occupied the site of its own previous labours. If this spot was left blank by the removal of the nest only a slight distance, the bee returned to the spot and showed great concern, but failed to recognize its nest, though it had passed over it in its homeward flight.

Some of the results of Fabre's experiments were rather ludicrous, and showed that the bee does not modify its actions according to circumstances as Honey Bees do. If he substituted a built and partially provisioned cell for one that had only just been commenced, the bee would proceed from that point in its own operations at which it had left off, and would make the cell much longer than necessary; but when it had made the cell a third larger it appeared to realize the absurdity of its action and left off. If such a substituted cell is already provisioned but not closed in, and the nest taken away was beginning to be filled with honey

and pollen, the bee would continue to pour in provisions, and finish by laying an egg where there was one already.

As we shall see in a later chapter, the hard cement of the Mason Bee does not secure its larva against the attack of parasites who eat up its provisions and starve it to death, or even eat up the grub itself.

Aristotle and Pliny describe the Honey Bee as taking the precaution, when having to fly home in a strong wind, to ballast itself by carrying a small stone. Réaumur supposes that in this matter they were misled by seeing *Chalicodoma* conveying one of the blocks of masonry she had constructed by cementing sand-grains together.

From the Mason Bee let us turn to a consideration of the Mason Wasp (*Odynerus spinipes*), which chooses for a building site the slope of a sand-bank where the sand is hard and firm, and therefore to be tunnelled with safety, though with great labour. Kirby and Spence tell us picturesquely that "its mandibles alone would be scarcely capable of penetrating [the hardened sand], were it not provided with a slightly glutinous liquor which it pours out of its mouth, that, like the vinegar with which Hannibal softened the Alps, acts upon the cement of the sand, and renders the separation of the grains easy to the double pickaxe with which our little pioneer is furnished."

It is both miner and mason. It bores a cylindrical cavity two or three inches deep, which

branches below into three or four cells; but instead of sweeping away the pellets it quarries, it uses them for building up around the mouth of its excavation a round tower, at first straight, then curved to correspond with the curvature of its own body. The use of this tower appears to be to make it difficult for any parasitical insect, during its own absence in obtaining provisions, to en er and lay eggs in the cavity. It is only a temporary erection, and therefore it is not made solid; the stones of which it is constructed, though firmly connected, leave little interstices, as though it were anxious to make its material go as far as possible.

The nest is furnished with a number of small green caterpillars which naturally curl into a circle when alarmed. These, of course, are first stung, so that they have little or no power of movement. The egg is laid in the far end of the cell, so that on hatching the grub first attacks the caterpillar that was first stung.

After filling up the cell with from twenty to forty small caterpillars, the Mason Wasp takes down her tower, stone by stone, and uses the materials for building up the mouth of the nest solidly. The building of this tower is therefore a fine example of economy of labour. Instead of dropping the material excavated from the hard sand-bank and having to collect it or similar material again for building up the entrance, she stacks it ready to hand, and in the doing of it contrives a shelter

which protects her progeny from the insidious attack of a deadly enemy. How like the operations of the human bricklayer who piles a stack of bricks within reach of his hand from which he can take them as wanted for building his wall!

The "deadly enemy" referred to above is the brilliant little Ruby-tail Wasp (*Chrysis ignita*), whose head and thorax are blue or green in different aspects, and the hind body red and gold, the entire body having a metallic polish that makes the little creature glow and flash in the sunshine. These wasps make no nests of their own, but are always on the watch for more industrious species that are provisioning theirs, and whilst the Mason is away hunting they pop in and leave an egg of their own. The *Chrysis* grub sucks the grub of the Mason Wasp dry, or in some cases eats up the food and leaves the rightful occupant of the nest to die of starvation. It appears to be mainly against the Ruby-tail that *Odynerus* builds her temporary towers; but Wood Ants (*Formica rufa*) have in some districts to be guarded against also.

Some of these Mason Wasps of the same genus (*Odynerus*) carry their labour-saving ideas farther, and look out for defects in human masonry. Where a chink has been left in the mortar they enter and enlarge it, making it symmetrical as they would have done had they begun the excavation. Others adapt key-holes, nail-holes, or any other perforations that are large enough, or can be made large enough by a little manipulation. In some cases it is

the other way about, and they have to partially block up a crevice that would be otherwise inconveniently roomy. Whatever the Mason's length may be, its breadth is very little, and it contrives the burrow to have only sufficient "elbow-room." There are many inquisitive birds about with a taste for fat little grubs, and the smaller the entrance holes to nests the safer for the defenceless grub. Ichneumon flies with long, slender ovipositors, and other parasitical insects of their own order, have to be guarded against so far as possible; but the latter are the more subtle, and often succeed in introducing their own eggs to the utter ruin of the Mason Wasp's plans. If the parasite does not begin by eating up its host, it devours all the provisions and allows the host to perish by starvation.

One species, *Odynerus reniformis*, described by Fabre, hangs its egg from the roof of the cell by a silk thread, a provision to protect the newly hatched grub from being crushed by movements of the score or so of small caterpillars that are placed inside after the egg is laid. From the egg-shell the young grub can reach down to its first caterpillar, and, about twenty-four hours later, when this is devoured, the grub is believed to cast its skin and to be sufficiently strong to take care of itself among the only partially stupefied caterpillars. It eats them in the order in which they were brought in.

Let readers who share the common enmity to wasps of all sorts bear in mind these facts about their utilization of caterpillars. Let such consider

how long it would take them to hunt for and destroy ten dozen small caterpillars, that are the exact tint of the leaves upon which they feed. This is the number that one of these Mason Wasps will requisition for the provisioning of the cells in one of these interesting structures. Every such wasp that is wantonly killed means that number of caterpillars allowed to grow and do incalculable damage to the choice plants of our gardens, it may be. Almost certainly, if a wasp is killed in our garden, it was there on a hunting expedition, and it is *our* garden that will suffer for our ignorant folly.

It might be supposed that the choice of a particular insect for the nourishment of her grub is a merely arbitrary proceeding on the part of the parent; but a circumstance narrated by the Peckhams throws doubt on such a supposition. They had opened a cell of *Odynerus conformis*, and in doing so had lost all but one of the caterpillars it contained. The grub "hatched on the morning after we had received it, sloughing off the skin of the egg, but remaining attached to it, and thus doubling the length of the thread by which it hung. The caterpillar was slightly separated from it, and it seemed to have no notion of feeling about for its food, eating nothing for twenty-four hours, but growing and developing nevertheless. We now piled up some caterpillars in contact with it, and it began to eat, but after its own caterpillar and as many as we dared take from [a nest of *O.*] *anormis*

were gone, it stubbornly refused to take soft, tender little spiders, or caterpillars out of our garden ; and it perished, a victim to prejudice."

The Wall Mason (*Odynerus parietum*) appears to be fond of proximity at least to human beings, for its nests are commonly constructed on the walls of houses, sometimes in the angles of the window-frames, but often on the seams of mortar between the bricks. She uses sand and mud, and mixes them with her own mouth-cement, which causes them to set like mortar. Sometimes she uses the "pointing" of the human mason or bricklayer, if this is not so rich in cement as to defy her jaws. Whatever the material, she turns it into cylindrical cells, which are usually joined end to end, so that we get a continuous round-backed ridge on the wall. Each of these cells she stocks with green caterpillars in turn. Where she is engaged on her building operations, the Ruby-tail may usually be seen as an interested spectator, watching for her opportunity to bring the Mason's labours to naught.

A little-known species—*Ceramius lusitanicus*—found in the Mediterranean region, makes its nests in the earth and connects them by a gallery two and a half inches long. It renders this gallery difficult of access to enemies by erecting a chimney-like porch after the manner of *Odynerus*. This precaution is very necessary in this case, because the cells are not provisioned and sealed up, but the larva is fed more like those of the Social Wasps

PLATE 8 — YELLOW-FOOTED MUD-DAUBER AND ITS NEST. — Page 80

The great daub of mud to the right has been built up by this long-waisted wasp, which has carried the whole of the material in small portions in its jaws. It is not so solid as it looks, however, there being many cells in the interior. The holes show where wasps have made their exit from these cells.

Photo by Author.

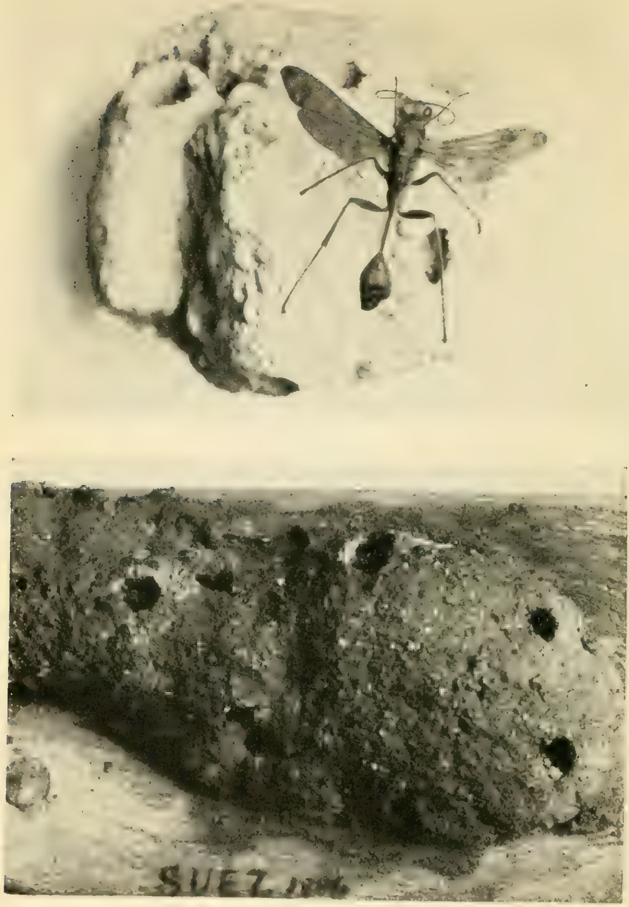


PLATE 9 MUD-DAUBERS. Page 82

In the upper photo an unfinished "daub" is shown with a single cell standing out from the mass, to illustrate the fact that all the cells are made separately, the interstices being filled in afterwards and the whole mass finished with a tolerably even surface as in the lower photo.

Photos by Author.

by the mother bringing them food from time to time. This food consists of a paste resembling dried honey.

The plan of suspending the egg by a thread from the roof of the cell is also adopted by *Eumenes*, another genus of Mason Wasps, of which we have a single British representative—*Eumenes coarctata*. This is the mason to whom we alluded as having advanced to the status of art potter, for its nests—often attached to the stems of heath plants—take the form of low, round vases, with short neck and turned-out lip. The nest is made of clay tempered with the wasp's own cement, and it consists of a single cell which, before the mouth is closed, is stocked with caterpillars and the wasp's egg. Sometimes it is placed on a broader surface than the twigs of a shrub afford, and in that case loses some of its grace, the bottom being flat to give it a better hold.

Eumenes arbustorum and *E. pomiformis* show that they are true Masons by building into the walls of their nests small stones, so that they have the appearance of having been built up of stones with clay to hold them together. (See Plate 7 for nests of *E. pomiformis*.) *E. pomiformis* occurs in the South of France, and Fabre, apparently describing this species, says that the fourteen or sixteen caterpillars with which the nest is provisioned are only slightly affected by the stinging (if, as believed, they are stung), for they are able to use their jaws and to kick out, as it were, with the hinder

part of the body. This power of movement would make them dangerous company for a delicate egg placed among them, or even for a newly hatched grub.

Here, then, is the reason why the egg is suspended. Should it be struck by the movements of one of the caterpillars, it would swing out of the way like a pendulum, and the newly hatched and tender grub can feed in safety from its swinging perch. A remarkable point in this connection, showing how several items are correlated, is the way in which the egg-shell splits up on hatching. From the point of attachment of the suspensory thread it splits into a sort of ribbon which in effect lengthens the thread and enables the grub to get nearer to its food.

Eumenes unguiculata, though it fashions a less-regular vase, provides three cells in the interior, each of which has its egg and its store of caterpillars. An Indian species, *Eumenes conica*, makes the mistake of constructing its nest with walls so thin that a parasite readily pierces them to lay its eggs. For this reason only two wasps were reared from a group of five cells, the parasites having destroyed the other three.

Several species of *Trypoxylon* (all the species are Masons) construct nests much after the pattern of *Eumenes*. One of these is mentioned by Bates in the account of his natural history exploration of the Amazons. He says:

"Their habits are similar to those of the *Pelopæus*:

namely, they carry off the clay in their mandibles, and have a different song when they hasten away with the burthen from that which they sing whilst at work. *Trypoxylon albitarse*, which is a large black kind, three-quarters of an inch in length, makes a tremendous fuss whilst building its cell. It often chooses the walls or doors of chambers for this purpose, and when two or three are at work in the same place their loud humming keeps the place in an uproar. *T. aurifrons*, a much smaller species, makes a neat little nest shaped like a carafe ; building rows of them together in the corners of the verandahs."

In Hawaii several species of *Odynerus* construct single-celled nests similar to those of *Eumenes*, but more cylindrical than spherical. They are fond of making these in a leaf that has been curled up already by a spider to serve as a nursery for her young ones, and in addition the young of a certain species of snail (*Achatinella*) like to crowd into the same refuge ; so that, as Mr. R. C. L. Perkins tells us, you may find a curled leaf occupied by these three kinds of tenants at the same time.

Mr. Bates tells us how another Mason Wasp utilizes the same clay-pit at Santarem, on the Amazon, from which the human inhabitants obtain clay for making their pottery.

"The most conspicuous was a large yellow-and-black wasp, with a remarkably long and narrow waist, the *Pelopæus fistularis*. It collected the clay in little round pellets, which it carried off, after

rolling them into a convenient shape, in its mandibles. It came straight to the pit with a loud hum, and on alighting lost not a moment in beginning its work, finishing the kneading of its little load in two or three minutes. The nest of this species is shaped like a pouch, two inches in length, and is attached to a branch or other projecting object.

"One of these restless artificers once began to build on the handle of a chest in the cabin of my canoe, when we were stationary at a place for several days. It was so intent upon its work that it allowed me to inspect the movements of its mouth with a lens whilst it was laying on the mortar. Every fresh pellet was brought in with a triumphant song, which changed to a cheerful busy hum when it alighted and began to work. The little ball of moist clay was laid on the edge of the cell, and then spread out around the circular rim by means of the lower lip, guided by the mandibles. The insect placed itself astride over the rim to work, and on finishing each addition to the structure, took a turn round, patting the sides with its feet inside and out before flying off to gather a fresh pellet. It worked only in sunny weather, and the previous layer was sometimes not quite dry when the new coating was added. The whole structure takes about a week to complete.

"I left the place before the gay little builder had quite finished her task: she did not accompany the

canoe, although we moved along the bank of the river very slowly. On opening closed nests of this species, . . . I always found them to be stocked with small spiders of the genus *Gastracantha*, in the usual half-dead state to which the mother wasps reduce the insects which are to serve as food for their progeny."

In the light of Fabre's experiments to ascertain the sense of locality possessed by wasps, it is no wonder that Bates's wasp did not follow the canoe. She, no doubt, hunted anxiously for her nest in the place where the canoe had been!

The species mentioned is related to the Sand Wasp (*Ammophila*) described in the previous chapter. Many species of *Sceliphron* (in which genus *Pelopæus* is now merged) are known in various parts of the world as Mud-daubers. It is scarcely a nice way of referring to skilled artizans, but the name may be regarded as a note of resentment on the part of householders who do not regard the often large masses of wasp-masonry exactly as ornaments to their doors, windows, and parlour walls. It is remarkable that so many of them should manifest this preference for human habitations.

Fabre mentions one (*Sceliphron spirifex*) that of all places for its nesting-site selects a nook in the broad open fireplace of the peasants of Southern Europe, where, although safe from the flames, it is not free from smoke. In spite of cooking operations that may be in progress the wasp flies in and out, between its nest and the outdoor source of

the clay or mud it needs for its building. In most species of this genus the large cells are formed one against another, in number varying from ten to fifty, and the whole are consolidated into one mass by plastering further mud or clay into the intervening spaces and rounding the composite structure off. It stores the cells with small spiders, and appears to kill these outright by its sting. When the first of the series is dropped into the cell the egg is laid on it, so that the wasp grub begins to feed on the least fresh of its food, and has to work through the whole series before decomposition begins, though one might suppose this would not take long in a fireplace. *Spirifex* on an average allows eight spiders to each grub, and these are consumed in about ten days.

Some of these *Sceliphrons* have learned to disguise their carefully constructed nests. Thus, an Indian species (*S. madraspatanus*), that comes into houses and decorates walls and furniture with its nests, appears to be desirous of meriting the name of Mud-dauber, for after the nest is complete as a comfortable habitation for the grubs, she sometimes gives a few artistic touches in the shape of radiating streaks of mud, which make it look as though a handful of mud had been thrown against the wall and had splashed. There are only from four to six cells in this nest, and each cell as a rule contains a score of spiders.

An Australian species (*Sceliphron lætus*), whose habits are very similar, adds to the finished nest a

few diagonal streaks of mud, which make the whole affair look like a piece of acacia bark. Although a piece of bark looks out of place on the wall of a house, it may be presumed that before the wasp developed a liking for human society it was in the habit of placing its nests on tree-trunks.

In parts of the United States the people suffer annoyance from the similar habits of another species of *Sceliphron*, and Burbidge figures one that he met with in Labuan, of which he says: "One of the most common and interesting of the domestic insects is the 'Mason Wasp,' a large yellow species which constructs a series of mud cells or a gallery of earth against the woodwork of the verandah or roof. In each cell, as completed, an egg is deposited, and ere closing up the cavity it is stuffed full of green caterpillars, which are then sealed up alive to serve as food for her larva when hatched out."

Mr. W. H. Hudson, when in La Plata, suffered from the pertinacity with which these mud-daubers would enter his dwelling, and his admiration for the beautiful mason and her industry was swallowed up in his disgust with her methods of filling her cells. He says:

"These insects, with a refinement of cruelty, prefer not to kill their victims outright, but merely to maim them, then house them in cells where the grubs can vivisect them at leisure. This is one of those revolting facts the fastidious soul cannot escape from in warm climates; for in and

out of open windows and doors, all day long, all the summer through, comes the busy, beautiful Mason Wasp. A long body, wonderfully slim at the waist, bright yellow legs and thorax, and a dark crimson abdomen—what object can be prettier to look at ?

" But in her life this wasp is not beautiful. At home in summer they were the pests of my life, for nothing would serve to keep them out. One day while we were seated at dinner, a clay nest, which a wasp had succeeded in completing unobserved, detached itself from the ceiling and fell with a crash to the table, where it was shattered to pieces, scattering a shower of green half-living spiders round it. I shall never forget the feeling of intense repugnance I experienced at the sight, coupled with detestation of the pretty but cruel little architect."

In some cases a Flesh Fly (*Sarcophaga*) has noted the stores of spiders and insects being taken in, and has concluded that they offer a good opportunity for the disposal of a few of her own eggs. The result is that the Mud-dauber grub perishes for want of food, and a like fate awaits the Flesh Flies owing to their inability to break through the thick walls of their prison.

Very similar to the constructions of these " Mud-dauber " Mason Wasps are those of an Indian bee (*Megachile lanata*), closely allied to our Leaf-cutter Bee (*M. centuncularis*), and strange to say it agrees with these wasps also in its liking for human dwell-

ings; but it looks out for some cavity or recess in which to place the nest. This is composed of clay or mud, and if space allows, several cells are placed side by side. During the latter part of "the rains" all things in an Indian household that have small cavities require to be carefully looked after, or the said cavities will be plugged up by this bee, whether they be rifle-barrels, bamboo rods, punkha holes in the wall, or the hollow revealed in the back of a book that is left open on the table.

The species of *Agenia*—which are closely allied to *Pompilus*, the burrowing Spider Wasp—are of the potter branch of the mason industry. Two European species (one of them British) make vase-like nests which they hide in tree-hollows, wall-holes, and similar places. *Agenia carbonaria*, which is found in the South of England, contrives a nest much like a wide-mouthed bottle; but it is not so accomplished in the potter's art as some of those we have mentioned, for it does not appear to have learned the secret of kneading its materials with saliva, and so they have not the proper permanency. For this reason they are not placed in exposed situations where the weather would soon crumble them. The little wasp has learned that such material would not be waterproof, and so she takes care to line the nest inside with a coating of glaze, probably supplied by her mouth, which serves to keep the contents dry. The cell is provisioned with spiders which are paralyzed by biting instead of stinging, and their limbs are broken.

Cœlonites abbreviatus constructs tubular earthen cells, which are attached in small groups to the dry stems of plants, with the mouths downwards. They are provisioned by the mother wasp with a paste said to resemble dried honey—probably a mixture of honey and pollen.

One of these Mason Wasps (*Abispa*) that is peculiar to Australia is much like a large *Odynerus*. Its beautifully constructed nest is so large that it might be thought to be the combined effort of a colony of Social Wasps, but it is entirely the work of one female. The entrance to it takes the form of a projecting funnel.

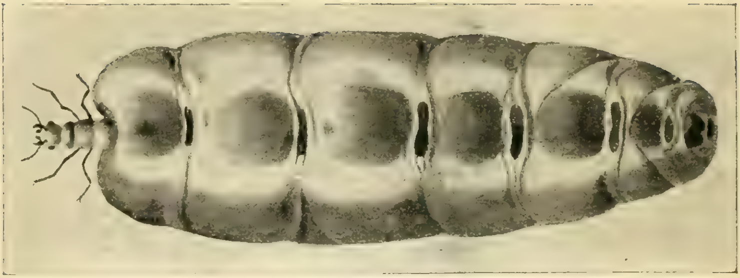
The East Indian *Rhygchium nitidulum* makes clay pots, like *Eumenes*, and stores them with caterpillars. The pots are attached to wood. Of an allied species—*R. brunneum*—Sir Richard Owen complained that it obliterates Egyptian hieroglyphics by plastering its mud cells among them. Some thousands of years ago, when an ancient Egyptian was being converted into a mummy, one of these wasps had the fortune to be wrapped up with him. When, in later times, Dr. Birch, of the British Museum, unrolled the wrappings of that mummy the wasp came to light, to prove that *Rhygchium brunneum* was an ancient Egyptian also.

The most important of the insect masons we have reserved to the last—the Termites or "white ants." It is probably unnecessary, at this date, to explain that these insects are not ants at all, and

PLATE 10 NESTS OF TERMITES OR "WHITE ANTS." Page 86

These huge erections are sometimes 20 feet in height, and represent the labour of many generations of builders. The one in the foreground has been cut open to show the galleries and passages of the interior, which are not so well planned and symmetrical as was formerly believed to be the case.

Drawn by T. Carreras.



The Queen Termite is the mother of the hill-nest. Her body, here shown of the natural size, is bloated with eggs, of which she lays many thousands per day.

PLATE II TERMITES OR "WHITE ANTS." Page 88

In the lower illustration the upper figure is that of a winged male; below to the left is a soldier and to the right a worker.

are not more closely related to ants than a bee is to a butterfly. The popular name, no doubt, was suggested because of some similarity in their social habits and marvellous organization, their permanent communities, and their care of the young. Their forms are quite unlike, and whereas the ant is encased in a hard and polished chitinous exterior, the termite is soft-bodied and pale, its integument apparently painfully sensitive to the action of light, judging from the care it takes to live and work always in darkness. It is to this latter sensitiveness that its supremacy as a mason and builder is, in all probability, due.

In one respect they do resemble ants—and hive bees—that is, in addition to males and females, there is a far more numerous sexless class upon whom devolves all the activities of the community, save only that of reproduction. But there is this difference between the sexless forms of termites and those of most ants, that in the former there is a further division into workers and soldiers. This is not any arbitrary assignment of duties by the community, it is a distinction enforced by nature, for both worker and soldier are—like poets—born as such, not made.

Both soldiers and workers are blind, but in spite of this fact they are very sensitive to light. The workers are well named, for upon them devolves all the labours of the community—the erection, repair, and extension of the termitarium or hill, the care of the eggs and young, the prison care of the

so-called royal couple, who have none of the prerogatives of human royalties.

The soldiers also are well named, for, like the rank and file in our armies, their duty is to sacrifice their lives for those who feed them. They were formerly thought to be formidable and pugnacious, but like the old-style Chinese army, accoutred to make themselves appear hideous and so frighten their opponents at sight, these soldier Termites are not nearly so formidable as they look. They are characterized by the great size of the head—in some species this is larger than the body—which is either developed into long spines and spears, or the jaws are increased to an enormous length. But all they can do when the termitarium is broken into is to seize the intruder with their jaws and hang on till they are destroyed, what time the more important workers are getting safely away into the narrow galleries and underground chambers where no enemy can follow them.

There are many species of Termites, and in the space at our disposal it is impossible to give any detailed account of them—a general statement of their work as masons must suffice. They get their living, it is true, as carpenters in the sense that they cut up and consume as food timber and other vegetable substances; but in constructive work they are masons. They drive mines and tunnels of great length underground, connecting hill to hill, but these tunnels are lined with masonry, and their communities are housed in the huge permanent

structures known as ant-hills or termitaria. These are built of earth and excrement mixed with salivary secretions which cause the compost to set into a mass of stony hardness.

So strong are these erections—varying from a height of a few feet to more than twenty feet—that they are used as a guard post by bull buffaloes keeping watch over the cows that feed around. Sportsmen use them as safe towers from which they can shoot big game in Africa, and Smeathman tells how himself and four others used such an erection as a look-out for passing ships. When the small size of the Termites is compared with the height of their buildings, we realize that these insects were the original inventors of the "sky-scraper," only the Termites are wiser and more artistic than their human imitators, for they mostly build in pyramidal form with a broad base instead of the hideous straight-sided excrescences that mar the sky-line in American cities.

The form of the termitaria is varied by the different species, and to some extent according to situation. Some species scarcely come under the designation of masons, since they construct nests of more papery material on the upper branches of trees. But of those that are indubitable masons some roof their cities with cupolas, some favour the Gothic style of architecture and run off into innumerable spires. An Australian species—known as the "Compass Ant"—builds wedge-shaped structures whose broad faces always look east and west.

The older travellers told of the invariable planning out of the interior into definite halls, royal apartments, nurseries, food stores, etc., and their sectional elevations were copied into all the natural-history works of the last century, just as were those of the "mole's fortress," which looked like an iron casting. Both have been shown by later investigators to be largely imaginary, or at least idealized. There are various chambers, it is true, and a special prison-cell for the female; but for the rest the termitarium appears to be made up mainly of labyrinthine passages, a style of architecture which gives much greater strength than the vaulted halls with wide-spanned domes.

It must be remembered that "ant-hills" of great size are the work of several—it may be, many—generations, and often of several species. Bates found at Santarem that the large hillocks contained colonies of several different species, each of which had a different way of utilizing the building materials and kept strictly to its own part of the structure—a further parallel with the "sky-scraper" that is let out in tenements occupied by different firms or companies!

There is no entrance to these termitaria evident from the exterior. They are all built up from the ground under cover, and the entrances and exits are at a distance, approached by underground tunnels. Only when a big batch of the winged males and females have reached maturity are the outer walls pierced. Then the workers

bite through to allow of the exit of the winged thousands.

"They clear the way for their bulky but fragile bodies, and bite holes through the outer walls for their escape. The exodus is not completed in one day, but continues until all the males and females have emerged from their pupa integuments, and flown away. It takes place on moist, close evenings, or on cloudy mornings: they are much attracted by the lights in houses, and fly by myriads into chambers, filling the air with a loud rustling noise, and often falling in such numbers that they extinguish the lamps. Almost as soon as they touch ground they wriggle off their wings, to aid which operation there is a special provision in the structure of the organs, a seam running across near their roots and dividing the horny nervures. To prove that this singular mutilation was voluntary on the part of the insects, I repeatedly tried to detach the wings by force, but could never succeed whilst they were fresh, for they always tore out by the roots.

"Few escape the innumerable enemies which are on the alert at these times to devour them: ants, spiders, lizards, toads, bats, and goatsuckers. The waste of life is astonishing. The few that do survive pair and become the kings and queens of new colonies. I ascertained this by finding single pairs a few days after the exodus, which I always examined and proved to be males and females, established under a leaf, a clod of earth, or wandering about under the edges of new tumuli. . . . I

once found a newly married pair in a fresh cell tended by a few workers" (Bates).

Thomas Ward, the Australian naturalist, gives us a picture of these erections, and their secondary uses, as he found them in the Port Darwin district. He says:

"Seven miles beyond the wood we came to a patch of most extraordinary-looking country. It was covered with enormous ant-hills, many of them nearly twenty feet high. They completely shut off our view of the surrounding country; and we seemed to be passing through a necropolis of strange tumuli. Many bones were strewn about, the place seeming to be a favourite haunt of the wild dogs, whose monotonous howling we heard both night and day, though we never saw more than five or six of the animals at a time. These ant-hills were, many of them at least, of great age, the sides rutted and seamed deeply, and often covered with a kind of brown, yellow, and reddish lichens.

"The colonists are fond of remarking that nobody has ever seen a freshly erected ant-hill, and that there is some mystery about their formation. This is simply a popular error. Ant-hills of all sizes may be found where these insects (Termites) abound. They are increased in size so gradually that their growth is not perceptible to the careless eye. By constant watching I have perceived that small hills are thrown up comparatively more quickly than they are afterwards increased in size. In the first year they may be brought up to a foot

in height; at the end of seven years it is a good hill that is three feet high. After that the increase is very slow—a hill of twenty feet high is probably several hundred years old. The highest hill I have measured, near the Burdekin River, Queensland, was twenty-two feet four inches. Hills of fourteen to eighteen feet are very common, both in Queensland and in the Port Darwin district.

"Ant-hills, especially the large and old ones, are generally crowded with parasites, of which the largest are rats and snakes. Whether or not these annoy the 'ants' I could not ascertain, but the latter are powerless to remove them. Quite large snakes burrow into the hills, and a multitude of the rats sometimes occupy these mounds, and I suspect prey upon the pupæ. . . . Of lesser creatures, such as lizards, centipedes, and beetles, the numbers in a hill frequently amount to thousands. All these, without doubt, prey on the Termites and their pupæ, and the Termites appear to have no power of retaliation.

"These insects, invariably called 'ants' by the colonists of the districts where they abound, are one of the most intolerable nuisances of the country. They undermine everything that is constructed of wood, and houses have been known to fall as the result of their burrowing habits, while chairs, tables, and other articles of furniture are often exhibited as curiosities, the arms, legs, etc., being completely hollowed by these destructive insects, and the whole article reduced to a shell scarcely

thicker than paper. Accidents often happen as a result of this hollowing habit of the termite, for it is impossible to detect the mischief done to beams, rafters, etc., until they give way" (*Rambles of an Australian Naturalist*).

IV

CARPENTERS AND WOOD-WORKERS

IV

CARPENTERS AND WOOD-WORKERS

The Termites with which we last dealt may be regarded as affording a natural transition from the subject of masonry to that of carpentry, for they are accomplished in both arts, though their skill as masons overshadows their work as carpenters except when they obtain access to human dwellings. Like the work of many other of the insect carpenters, the industry of the Termites as wood-workers is of a destructive character, the wood being consumed as food, and in this case only used for constructive work after it has passed through the digestive apparatus and assumed an entirely different character. The higher grade of insect carpentry is seen in the work of the Carpenter Bee and the Carpenter Ant.

The Carpenter Bees (*Xylocopa*) are natives of warmer countries than our own, but several species are found in the South of Europe, and the best known of them (*X. violacea*) extends its northern range as far as the neighbourhood of Paris. The details of the industry of this bee were observed and chronicled years ago by Réaumur, whose account

was so accurate and complete that little has been added to it by later investigators. These insects are the largest known bees, and are of portly build, much like a large Humble Bee. They are of dark violet or black colour—though some species have yellow males, but the males do not count so far as the subjects of this book are concerned.

The female, having passed the winter in some snug corner, awakens to the important duties of life in the spring, and looks out for some post or pole that will serve her purpose; for she does not touch living wood. As a proper carpenter she sees that her material is well "seasoned." In the scheme of nature, which does not take account of man's acquired whims which have developed into necessities, all dead (*i.e.* not growing) timber has got to be cleared away as speedily as may be; and so a number of creatures devote part of their lives to this laudable object of clearing away used-up material and making it available for fresh uses. This they do either by eating it entirely as the Termites do, or by piercing it with holes and tunnels to admit air and moisture which soften the interior and make it available for workers with less-powerful jaws.

It is, of course, annoying to man to find that his fence and gateposts, his garden stakes, and even the rafters and floors of his house, are regarded as so much of nature's waste which must be broken up and scattered. If he wishes it to be respected as his private property let him put his mark upon

PLATE 12 NESTS OF CARPENTER-BEE. Page 98

The shafts bored in dead wood are divided into cells by partitions of agglutinated wood-fragments. These are provisioned with a mixture of honey and pollen and an egg laid in each. The cells show succeeding stages in development, beginning with the egg in the lower right-hand cell.

Drawn by T. Carreras.

PLATE 13 — MINES OF ELM-BORING BEETLES. — Page 114

The bark of the elm-tree is frequently found pierced with shot-holes. If the bark is removed, a large number of borings will be found to extend from each side of a central gallery. A Scolytus beetle has laid her eggs along the walls of this gallery, and the grubs on hatching pierce tubes side by side.

it by painting its surfaces, dipping it in creosote, or coating it with some other substance noxious to insects.

Having obtained a post suitable for her purpose, the Carpenter Bee sets about her work by cutting with her jaws an oblique tunnel about half an inch in diameter. Before this has extended far into the wood she alters the direction of further excavation and makes her boring run straight downwards. As she gnaws the wood it is reduced to the condition of sawdust, and this all has to be carried out of the hole, or her further efforts would be brought to a standstill. But instead of scattering the excavated material, as some of the miners in sand and earth do, she keeps it all together in a heap to be available for use later on.

She cuts and cuts away until her tube is a foot or fifteen inches deep and of equal width throughout its length. At the bottom she gives it a turn again to the exterior. Having performed this great work, she proceeds to what, by comparison, may be termed cabinet-work, the finer and more intricate section of the carpenter's art. Her task is to divide this deep shaft into about a dozen chambers, each about an inch in depth, each for the reception of a single egg and a sufficiency of food for the full development of the bee-grub that is to hatch out. This takes the usual form among these solitary bees, of mixed pollen and honey.

Having made such a deposit at the bottom of her burrow, she has recourse to her heap of saw-

dust. Taking a little of this material, she mixes it with a salivary secretion, and forms it into a ring around the wall of her shaft about three-quarters of an inch from the bottom. When this is set firm she constructs a similar ring within the circumference of the first, and so on until she has a complete floor about an eighth of an inch in thickness, marking off her lowest cell. Upon this she lays another egg and piles up another heap of provisions ; makes a second floor, and repeats these operations until there are about a dozen separate cells one above another from the base to the summit of her shaft, each with its egg and food.

If the thickness of the post is sufficient, several parallel shafts are made. Fabre has shown that if she can obtain a hollow reed of the necessary thickness, she has sufficient of the labour-avoiding spirit to be content with it. She will also repair nests of previous years to make them serve for her brood.

It will be evident that the elaboration of these floors from sawdust, and the gathering of food for such cell must consume some time, so that the larva in the lowest cell must finish its development before the one next above it in this tenement-house. If the first fledged had to emerge where the mother bee began her labours, at the top of the shaft, it would have to pierce through all the floors—and incidentally, perhaps, through several of its brothers and sisters—before it could gain its liberty. This is the reason why the Carpenter

made that lower exit. The bee grub at the time of its pupation fixes itself with its head downwards against the floor of its cell; and so, naturally, the new-born bee cuts through the floor and makes its way through the already vacated cells below.

One regrets that the Carpenter Bee has not crossed the English Channel and added its name to the list of British Hymenoptera. But if we cannot boast of one of the largest of bees among our fauna, we have one of the smallest that is also a clever artizan—*Ceratina cyanea*—whose metallic blue body only measures a quarter of an inch. It is related, moreover, to the burly Continental carpenter, and shares its habits, though it works in softer materials, as seems fitting to its diminutive size. *Ceratina* needs no bulky post to accommodate its series of cells. Everybody knows that the long shoots of the bramble that have borne this autumn's crop of blackberries will die off in the winter and become brown and brittle. Next spring *Ceratina* will be taking stock of these and looking for one that has a broken end. Into this she will tunnel, clearing out the pith to the length of about a foot, dividing the cleared space into tiny cells, laying an egg in each and leaving a suitable mass of food. The partitions between the cells are contrived out of the pith-fragments glued together by means of her saliva.

In speaking of the provision of a lower exit from her nest by *Xylocopa* we suggested that but for this arrangement the newly developed bees might

have to pass through the bodies of their less-ready kindred; but if we are to judge by the behaviour of another little carpenter, *Osmia tridentata*, there is no likelihood of such action being taken. There is such a thing as altruism among insects, though it may be only instinctive altruism.

Our native *Osmia leucomelana* usually drills out the dead bramble-stems like *Ceratina*, and constructs its cells of the pith, placing them end to end. *O. tridentata* is a Continental species with similar habits, and as it has been made the subject of some interesting experiments by Fabre we select it for description. Some other species are masons and excavate sand or clay. Making a cylindrical boring into the bramble-stem, *O. tridentata* does not trouble to clear out at first more pith than will serve to allow her passage. Then at the far end of her burrow she constructs an oval cell, using for the purpose the pith she has left on the stem, and stores it with pollen, honey, and an egg. She shuts up this cell by constructing another and using the material cut out, mixed with salivary cement, to form a partition across the stem. So she proceeds until she has constructed and furnished ten or twelve cells.

Now, it is natural to assume that, as in some similar cases, the egg that was deposited first would produce the first bee ready to emerge, and a difficulty arises as to the manner in which it makes its escape. Dufour boldly concluded in a similar case that it was from the last-made cell that the

first bee of the brood escaped, and so on in inverse order to their age with the entire brood. It is not surprising to learn from Fabre that this is not the case. He found that as a fact the order in which the eggs were laid had no relation of necessity to the order in which the perfect insects emerged from their cocoons.

When one of the bees has completed its development it tears open the cocoon that has contained it, and then pierces the partition erected by its mother between it and the next cell. Should it chance to be the one nearest the entrance there is, of course, no difficulty. It is free. But if its egress is blocked by another cell, or more, it will not violate the cocoon, but waits, cramped up but patient, for days until the other has emerged in front of it. It may, after thus waiting and feeling the impulse of the work it has to do, strive to break through the wood of the bramble-stem, or clear a passage beside the cocoon, but it will die rather than injure a cocoon it knows to be occupied by a living pupa of its own race. If something has gone wrong with one of the outer cells, so that emergence from the inner ones is delayed more than a week or two, they will probably all die.

Fabre blocked such a tunnel with cocoons containing dead specimens of the same species, and found that in every case the emerging bees had no scruple as to breaking through such cocoons: they *knew* the inmates were dead. He then took a reed that contained the cells of another species of *Osmia*

(*O. detritus*), and blocked it with cocoons containing living grubs of *Solenius vagus*. As these were not of their own race, the *Osmia* had no compunction in destroying them. Although living, they were of no more value in their estimation than their dead kindred.

Cemonus unicolor, a little black wasp only a quarter of an inch long, also forms its nests in these dead bramble-stems, which, by the way, offer a very convenient means of making acquaintance with the nesting habits and general history of some of our hymenopterous insects. The dead stems that have had their broken ends plastered up by the mother bee have only to be collected and stored in a suitable gauze-covered box until spring, when the bees will emerge and their identity can be established. A careful paring of the wood along one side of the stem will then reveal the structure of the contained cells. This species provisions her cells with Aphides, the detested "green fly" of the gardener. Sometimes, instead of bramble-stems she makes use of the bullet-galls of the oak, enlarging the borings through which the rightful inhabitants have emerged. A very similar but slightly larger black wasp, *Pemphredon lugubris*, bores into the soft wood of decayed beeches. Both these species occur in Britain.

Several of the burrowing wasps of the genus *Crabro*, of which we have thirty British representatives, make their burrows in bramble-stems and similar material. The grubs before pupation spin

tough brownish cocoons. The perfect insects are black and yellow (some all black), often banded in a very wasp-like fashion, and they have broad, square-cut heads. The usual food stored for their grubs consists of two-winged flies (Diptera), and in some cases each species of *Crabro* has a particular species of fly it uses for this purpose; but there are several remarkable departures from the rule. Three of our native species (*Crabro tibialis*, *C. clavipes*, and *C. capitosus*) use bramble-stems for their burrowing operations. *C. signatus* and *C. dimidiatus* bore into posts and stumps, the latter species storing up blue-bottle flies. *C. leucostomus* has a preference for the soft wood of decaying willow-trees, and as grub-food selects the bright-green fly *Chrysomyia polita*. *C. quadrimaculatus*, *C. chrysostomus*, and *C. interruptus* also burrow into dead wood.

The Peckhams found *C. sexmaculatus* burrowing into the sound wood of an above-ground root of the lime-tree. Five of them were sinking their shafts side by side—

" . . . sawing and cutting in the most humdrum and practical manner. One of them, presumably the earliest riser, was well down in the root, and came backing up once in a while, pushing a lot of wood-dust out of the hole. This was spread out by means of legs and mandibles, and was then blown away by the fanning wings of the little worker, who circled about just above the ground until the last grain had disappeared. . . . After this series of

actions had been repeated several times, the wasp flew away to hunt. We afterwards found that she had finished the third in a set of cells leading from a main gallery. On her return we delayed her to see what she was carrying. She showed no fear, but alighted close by, and while she was trying to transfer to the third pair of legs the fly that she was clasping with the second pair, it escaped and flew gaily away. Flies are plenty, however, and she soon had another, which she was permitted to store; and from that time she worked busily until we left her at noon. It took her from two to ten minutes to catch her fly, and at each return two or three minutes were spent in the nest.

"On opening her tunnel some days later, we found within not only flies, but long-bodied gnats, and all of them seemed to have been brought home uninjured. When the freshest cell was opened some flew away, others were walking about, and all were lively. The wasp egg was laid on the under side of the neck; and although we could not be certain of the exact time of laying, we thought it hatched at the end of thirty-six hours. From ten to sixteen flies were provided for each larva."

The same observers found a colony of ten or twelve nests of our *C. interruptus*, made in a stranded log on the shore of Lake Michigan, and to their surprise the wasps were storing them with little white moths, which they packed length-wise in the nest. They also observed *C. stirpicola* excavating

a bramble-stem, and they comment upon the contrast all these *Crabros* offer in their quiet and calm, even stately, methods of working to the restless and fussy ways of *Pompilus* and *Ammophila*. They found that this species at least works all through the night. One individual was kept under close observation, and they found that she worked continuously at her carpentry for forty-two hours on end. The only interval she allowed herself for rest during that long period was one of ten minutes when she was about half-way through her task.

Her tunnel was found to be thirty-nine centimetres (= 15½ inches) in length, with a width of about three and a half millimetres. This would be divided by partitions into ten or twelve cells. Unfortunately, after finishing her forty-two hours' spell of carpentry, and closing up one cell with its eggs and stores, she must have met with some mishap on her hunting expedition, for she never came back to complete her nest. It was impossible to think that anything short of loss of life had kept her from it. With insectivorous birds about, this, alas! is only too common an end to such enterprises.

Some species of *Odynerus* differ from those already described under the head of Miners by making burrows in bramble-stems and the like. Among these are three of our native species—*O. melanocephalus* and *O. lævipes* which adopt bramble-stems, and *O. trifasciatus* which prefers old palings. The North American species, *O. conformis* and

O. anormis, likewise tunnel in the stems of bramble and raspberry. In some nests of *O. conformis* opened by the Peckhams they found each cell contained about twenty-four small caterpillars so tightly packed that after taking them out to count them they were unable to put them all back, and although motionless in their narrow quarters they become quite active when relieved from pressure. Our *O. lævipes* is said by Saunders to be not content with the natural lining of pith to its burrow, but takes the trouble to give this a coating of cement made from fine sand.

Certain of the true Ants are accomplished carpenters. We need not go beyond our shores for a good example, which we find in the Jet Ant (*Lasius fuliginosus*), a little shiny black ant. Its natural nesting-places are in old trees and stumps, but it is not above taking advantage of worked wood for its purposes. Its method is to carve out wide and ramifying galleries in the wood, leaving partitions and supporting columns between the stories. It follows no architectural plan in its operations, each worker apparently following its own sweet will and its own idea of what is advantageous to the colony. One starts a corridor and works until it is tired, then leaves off, and any other ant that wanders that way carries the work a bit farther, probably on a different plan. These corridors are often cut out side by side, but on different levels, so that when later the dividing walls are cut through in places the result is rather higgledy-piggledy.

We have alluded to these excavations as nests, but they are really only nests in part, for the ants can occupy only an infinitesimal part of the whole. Insect structures intended solely for nests have some relation to the size of the inmates, and passages are cut allowing little more than free headway; but the scale of *Lasius fuliginosus*' home is much as though a man built his residence on cathedral lines. Some of the Carpenter Ant's floors, indeed, remind one of cathedral architecture with their supporting pillars and arches.

This ant builds up as well as pulls down, for where a gallery or corridor has been cut out without any apparent regard for particular uses, it will afterwards erect partitions to divide it off into small rooms. These partitions are elaborated out of wood-dust mixed with saliva and spread out in thin sheets, so that it dries as cardboard. Every part of the wood they have worked turns black, as though it had been scorched, and the nest, as well as the ants, gives off a pungent aromatic odour.

Lasius niger, which usually makes its nest in the ground, sometimes constructs it in rotten wood. The Jet Ant, it should be observed, does not work in such soft material. The wood selected is firm and strong, and sometimes is that of a growing tree.

Of an American Carpenter Ant (*Camponotus pennsylvanicus*) which normally makes its nests in tree-stumps, much after the manner of our Jet Ant, McCook has shown the readiness with which

it can take advantage of the shelter afforded by a human erection. A colony of this ant had established itself in a mill and had selected as a nesting-place a beam above a staircase. They had found a crack in the wood and used it as a convenient entrance. From this point they drove tunnels far into the beam, and enlarged parts of these into corridors and chambers.

The wood cut to small fragments by their jaws was taken back to the entrance and there dropped. But it accumulated in an incriminating heap on a cross-beam only a foot and a half below. So a company of workers was told off to clear it away as it fell. This they did by carrying it bit by bit to the edge of the beam and dropping it over. But this did not get rid of it, for it fell upon the stairs, where it might equally call attention to the presence of the ants. Many of the burrowing Hymenoptera, whether working in wood or masonry, are equally solicitous to remove such evidences of their presence, which might otherwise give the clue to their enemies. A gang of ants was set to work on the stairs to scatter the tell-tale wood-dust farther away. Now these stairs were regularly swept down every morning by the mill-people, and after a time this fact by some means became impressed upon the minds of the ants, for they withdrew the staircase workers and contented themselves with the dispersal of the debris constantly falling upon the cross-beam.

These ants are not rapid destroyers like the

Termites, for after they had been at work for eight or ten years the beam was taken down and it was found they had only penetrated to a length of two feet. The thickness of the beam was seven inches, so that this area was considerable. The beam was cut through the affected part, and was found to be well excavated, with the floors, arches, and columns left, much as in the work of the Jet Ant, and as in that case well blackened.

The anxiety of this Pennsylvanian ant to dispose of the evidences of its industry is shown in another incident mentioned by McCook. A small maple-tree grew in one of Philadelphia's streets, to which the ants had obtained access through a crevice in the bark. From this crevice the wood-dust was ejected and, of course, formed a tell-tell heap on the side-walk. Here, again, a couple of ants were busily engaged in disposing of it by carrying it grain by grain to the kerb, and dropping it over into the gutter. After every such performance the ant would carefully brush her mouth with her fore-feet to make sure there were no fragments of wood-dust adhering to it.

The European species *Camponotus herculeanus* has similar wood-excavating habits. In South America there is a carpenter ant known as *Cryptocerus atratus*, which is remarkable for the spines on its thorax and at the back of its broad head. It perforates the dead branches of trees and woody climbers. The entrance to its nest consists of a few neatly drilled holes which are the beginnings

of long galleries. These are connected within by other galleries. *Colobopsis* lives in a similar manner, and for the protection of the colony keeps a big-headed worker on duty as a sentinel at the doorway. The worker's head just fills the space, and its jaws are ever ready to argue the matter with an unwelcome caller. One who has the right of entry is admitted by the worker withdrawing backwards.

Among the beetles there are a number of accomplished carpenters, some of them spending several years in the excavation of long burrows in trees, others engaged for generations in what the householder considers the more reprehensible business of drilling into his most cherished articles of wooden furniture and reducing them to fine dust. In the days when our navy consisted of wooden ships, some of these beetles were in permanent league with our enemies in the effort to destroy these wooden walls. It is not necessary to deal at length with these carpenter beetles, for their methods are much the same in many cases. A few examples must suffice.

The smaller of the carpenter beetles content themselves with tunnelling in the bark of trees, and such attacks are frequently regarded as of little moment to the tree, but they have been shown in some cases to interfere with the normal flow of the descending sap, and so produce an unhealthy condition which renders the tree susceptible to the attacks of more destructive species. Moreover, damp finds its way into these borings, also the spores of wood-destroying fungi which complete the work

begun by the insignificant beetle. It must be understood that when we speak of carpenter beetles we really refer to the insect in the grub stage. Some of the beetles as perfect insects indulge in wood-boring to some extent, especially females to deposit their eggs in a suitable position, but the real work of wood-boring is performed by the larvæ.

These insects are little known to any but the coleopterists, owing to their secluded lives. One whose ravages are most familiar is the Bark Beetle (*Scolytus destructor*), because one can often see a dead elm from which the bark has fallen, revealing the characteristic feather-like sets of burrows. There is a central burrow from which on either side other burrows run off at right angles to the central burrow, and at first parallel to each other. This pattern is brought about in this manner: the mother beetle bores the central burrow, and lays her eggs to the number of about fifty at pretty regular intervals along each side of it. When these eggs hatch, the young grubs set to work, each forming one of the side galleries. It is remarkable that every one of them should start off at a right angle and continue his burrow away from the central avenue.

These side galleries as they advance from the centre increase in breadth, an indication of the gradual increase in size of the carpenter. To accommodate this extra width without the whole of the side-burrows coalescing at their ends, it is

necessary that a slight radiation of all should take place, but how this is accomplished by grubs that are entirely shut off from communication is something of a mystery. The explanation is, probably, that each grub can hear the action of its neighbour's jaws transmitted through the cells of the bark and so can judge what is the proper line for its own excavation to take.

The Bark Beetle is quite small—not more than a quarter of an inch long—and black or brown in colour. Its smallness would appear to indicate an insignificant enemy to the timber grower, especially as it never penetrates deeply into the wood. Its burrows are half in the bark and half in the surface of the sap-wood. The completion of the work of the grub is made evident by the appearance of a number of what appear to be shot-holes in the bark. These show that the insect having lain for a time as a chrysalis in the broader end of its burrow has changed to a beetle and eaten its way out through the bark. The combined work of the one brood extends over a space of about six inches by four, and the result has been to kill a patch of bark of that size, so that sooner or later it separates from the sapwood and kills that too, by stopping the downward flow of the sap at that place.

There is some difference of opinion as to whether these beetles attack trees that are really healthy, or whether a certain condition of sickliness is not necessarily precedent to the success of the grubs. If the circulation of the tree were good, the burrows

would be filled by the descending sap and the grubs would be drowned by it.

There are two things in connection with *Scolytus* that should be reverted to. It has sometimes been stated that the side burrows starting off at right angles from the central boring is due to a remarkable instinct which leads the insects to this course in order that they shall avoid breaking into or crossing those of their brethren. Instinct has nothing whatever to do with it; it is a case of "Hobson's choice." Any one who has stripped off bark from an attacked elm knows that all these burrows are closely packed with powdered bark that has passed through the digestive organs of the insects. If the newly hatched grubs did not turn their attention to the sound bark before them they would have to feed upon this excrement.

Another statement we have seen made is that the larvæ never break into neighbouring burrows. As a rule they do not; but we have met with many cases in which they have done so, and we have seen examples in which one set of burrows have gone right across another set at right angles.

There are other beetles allied to *Scolytus* that attack the bark of trees. Two of them—*S. rugulosus* and *S. pruni*—belong to the same genus and attack plum-trees in a similar way. *Hylesinus fraxini* makes a similar arrangement of burrows in the ash-tree, and these are frequently evident in split ash-poles that have been used for fencing, and from which the bark has fallen. *Tomicus typographicus*

was so called by Linnæus on account of the letter-like character of some of its tunnels. Small beetles of the genera *Pissodes* and *Bostrichus* also perform their carpentry work in the bark of various trees.

But *the* carpenter among beetles is the grub of the Stag Beetle (*Lucanus cervus*), the largest of our native species. It spends four years in this condition and attains a considerable size, so that it would be a wood-destroyer to be dreaded were it not for the fact that it restricts its attention to those trees whose timber is decaying. It is therefore regarded as harmless. At the end of the larval period it makes a cocoon and changes to a pupa, in which condition it rests for a short period only, soon assuming the perfect form, but then remaining inactive for some months, only issuing to public view when the warm evenings of June have arrived, when in the southern counties it may be seen in great numbers flying about the lanes and fields. Its pabulum is chiefly oak, but it is often found in old willows. Two allied species, *Sinodendron cylindricum* and *Dorcus parallelopipedus*, have similar habits, but are comparatively rare.

Lymexylon navale differs from these in attacking solid, hard wood into which it bores long cylindrical holes. In the days when our navy depended upon sound timber the ravages of this beetle used to cause alarm, but now that we no longer grow timber trees seriously, but mainly as cover for game, it appears to have lost its character as a pest. It certainly no longer obtrudes itself upon public

attention, and even the coleopterist does not reckon it among common insects. But this is probably due to the fact that our forests are not what they were.

Anobium striatum is the well-known (by its works at least, if not in person) little beetle that bores the numerous pin-holes in our choice old furniture; and its larger relation, *A. tessellatum*, does similar work in beams. They are known as the "Death Watch," whose tapping, heard only in the stillness of the sick chamber, was formerly held to be a sure presage of the patient's early death. They are near relations of the "Biscuit Weevil," which may be regarded as a carpenter from the fact that it operates on biscuits that are as hard as wood; but not content with drilling passages, it demolishes the whole.

The grub of *Nacerdes melanura* has a special liking for working in floating or water-logged timber. It may be found along our sea-coasts in timber that has been brought down the rivers in flood, or that has been cast up by the sea.

Most of the larvæ of the enormous family of beetles known as Longicorns (*Cerambycidæ*), of which more than twelve thousand species are known, live on or in wood and the stems of softer plants. The Oak-pruner (*Elaphidion villosum*), of North America, feeds in the limbs of oak-trees, and cuts across them in such manner that they fall to the ground, the grub evidently preferring its wood dead.

The Girdler Beetles (*Oncideres*) of the same continent achieve the same end by a different method. The mother beetle, having deposited an egg in a small branch, cuts a deep groove, girdle-fashion, around it, so that the flow of sap is stopped and the length of branch snaps in the first wind and falls to the ground. When the wood containing any of these larvæ gets worked up by human carpenters into articles of furniture, the drier conditions appear to greatly lengthen the development of the insect, owing to the wood being less nourishing. Thus *Monohammus* has been known to issue from furniture that was fifteen years old; and in another case a longicorn beetle issued under conditions which made it probable that its development had been spread over forty-five years. The grub of *Buprestis splendida* is known to have existed in the wood of a table for twenty years.

The beautiful Musk Beetle (*Aromia moschata*), one of the finest of our native beetles, spends its larval existence in boring holes deeply into the timber of old willow-trees. The beetle makes its presence known by giving off an odour which closely resembles that of the sweet-briar rose. The deceptively marked Wasp Beetles (*Clytus*) are also carpenters in their larval days, excavating long tunnels in the thicker branches of trees. We have several times unwittingly reared a half-dozen or more of these beetles from a piece of such a branch only a few inches long, the piece of wood having been brought home because it supported some fungus.

PLATE 14 BORINGS OF A BEETLE GRUB. Page 118

A beautiful shining blue wood-boring beetle is here discovered in the grub stage on tearing off the bark of Scots pine. The beetle never attacks growing timber.

Photo by Author.

PLATE 15 THE TIMBERMAN. Page 120

This wood-boring beetle is distinguished by his pair of fine antennæ. Those of the female (above) may be described as long, but those of the two contending males are very much longer. This beetle is very destructive to pit props in coal-mines. The grub and the chrysalis are shown in the lower part of the picture.

Drawn by T. Carreras.

Whether the fungus had prepared the wood for the beetle, or *vice versa*, is an open question.

Fir wood that has been turned into rafters often contains the larvæ of *Hylotrupes bajulus*; and as the perfect beetle that makes its exit therefrom is about three-quarters of an inch long, it will be understood that considerable damage is done. Not only is the grub gifted with good cutting tools, but the beetle in making its escape from the scene of its larval industry is able to cut through obstacles. Sometimes the rafters are in a roof which is covered with sheet lead, but if this lead is across the path of the beetle that is eager to make its first acquaintance with light and air the lead must be perforated by the beetle's jaws.

The Rev. W. Kirby mentions that he received from Sir Joseph Banks a piece of sheet lead that had been so drilled. The piece was only eight inches long by four broad, but in that small area there were no fewer than twelve oval holes, of which the longer diameter was a quarter of an inch. In most cases bad plumber's work would be set down as the cause of such a roof leaking, no one thinking of ascribing such work to a beetle. The Timberman (*Acanthocinus ædilis*) in a similar way is destructive to pit-props in coal-mines. *Rhagium inquisitor* bores under the bark of willow and ash, and *Rhagium bifasciatum* burrows in the wood of pine-trees.

A species of *Histeridæ*, found on the Amazons, is described by Bates, not so much as a carpenter,

but as the carpenter's gimlet. This beetle (*Trypanæus*) differs from most of its congeners in being cylindrical. Its object is to tap the burrows of other wood borers and eat them in their retreats. He says, "They drill holes into solid wood, and look like tiny animated gimlets when at work, their pointed heads being fixed in the wood, whilst their smooth, glossy bodies work rapidly round, so as to create little streams of sawdust from the holes."

But enough of these carpenter beetles; we must glance at a few moths whose caterpillars have adopted this industry as a livelihood. First of these, on account of its superior size, is the larva of the Goat Moth (*Trypanus cossus*), which ordinarily attains a length of four inches, with a thickness of half an inch. It spends three years boring tunnels into the heart of sound trees, including poplar, willow, oak, elm, and ash. So vigorous a tree as an oak may take several generations of Goat caterpillars to kill, but when the tree is dead the caterpillars are said to leave it. Before each winter it hollows out a space in its tunnel, and spins a comfortable temporary cocoon in which it lies inactive during the cold weather.

When full-fed it leaves its burrow, and seeks about for light loose material in which to spin its final cocoon. This may be in some *rotten* wood of the tree whose hard parts it has been eating, but as a rule it has to wander away to find what it wants. At such times (in autumn) one may find them wandering about roads. On one occasion, in

Ireland, in company with Mr. H. J. Turner, F.E.S., we came across a poplar-tree on the bank of the river Nore which was completely riddled by this insect, so that it was very easy to tear away the wood that had been left and so reveal dozens of the larvæ of various sizes, showing that several generations of them were working as contemporaries. The burrows were attended by hundreds of a little beetle (*Soronia punctatissima*) that had not previously been found in Ireland. They were feeding upon the frass of *Cossus*.

The Wood Leopard Moth (*Zeuzera pyrina*) tunnels in the living wood of apple, pear, elm, poplar, and horse-chestnut, but its work does not appear to be of a destructive character; it has even been declared that fruit-trees attacked by it bear more abundantly than their neighbours that are not affected by it. The larva spends two or three years in the tree, pupating in its burrow; and the chrysalis has the rings of its body furnished with spines, so that by the alternate contraction and expansion of its segments it can force its way towards the mouth of its burrow when it is about to assume the winged condition.

The beautiful little moths known in the aggregate as the Clearwings (Sesiidæ), are all carpenters in the larval condition. They then bear a very close resemblance to the grubs of wood-boring beetles, but when they have reached the winged condition they are more likely to be taken for hymenopterous insects by the non-entomological observer. Most

of those whose life-history is known in detail are larvæ for nearly two years. They make straight vertical shafts in the stems or roots. One of the best known of the group is the Currant Clearwing (*Sesia tipuliformis*), which bores out the centre of black and red currant stems, entering above and working towards the base of the stem. Just before the emergence of the moth the chrysalis works its way through the thin skin-like bark, and sticks out some distance.

One of the largest of this group is the Lunar Hornet Clearwing (*Trochilium crabroniformis*), which is not like a hornet, as its names indicate, but very like a wasp when the insects are seen apart. Its caterpillar mines in the stems of willow, sallow, and poplar. Before becoming a chrysalis the caterpillar prepares for the egress of the moth by carving a way out to the air and spins a cap for the exit in which it so artfully mixes up some fragments of the bark that the cavity can scarcely be detected for what it is.

The caterpillar of the Light Orange Underwing (*Brephos notha*) becomes a carpenter only when it has nearly reached the end of its existence as a larva. Up till then it feeds upon leaves of aspen, spinning two of them together to hide it from public observation, but when it feels that its feeding days are over it bores into the bark or the sap-wood beneath, hiding its entrance by making a cap similar to that of the Hornet Clearwing, and then changes into a chrysalis. The moth has

PLATE 16 A TIMBER BEETLE.

An example of a numerous family whose grub stage is spent mining in the trunks of trees. Some of these have been known to issue from furniture many years after the timber was cut.

THE TRACK OF A DESTROYER. Page 122

A split branch of wayfaring-tree showing the burrow made by the wood-boring caterpillar of the orange-tailed clear-wing, a member of a family of small but beautiful moths.

Photos by Author.

PLATE 17 — HORN-TAILED WASPS — Page 124

A couple of huge Saw-flies whose grub-stage is spent in boring into the wood of pine-trees. This stage lasts for several years, and it frequently happens that the timber containing the grubs is used for building purposes without suspicion of their presence. The mature insects emerging from the woodwork cause consternation to households; but they are not stingers.

Photos by Author.

only to press its head against this cap to push it out.

Before concluding this chapter a word should be said about the Saw-flies (Tenthredinidæ), as nature has provided them with saws, though as a rule they only use them upon leaves and green shoots. It is only the females that are provided with these useful tools, and they use them for cutting a slit in which to deposit their eggs. A large kind of Saw-fly, however, known as the Large Horn-tail (*Sirex gigas*) has, instead, a powerful drill with which she bores holes in the bark of pine-trees for the purpose of laying an egg in each of the holes she drills. The drill has a protecting sheath in which it lies when not in use. It is three-quarters of an inch long, and is hinged so as to be used at right angles to the body. The grub which issues from the egg is a notable carpenter too, but it works with its jaws, and spends several years in excavating a nice long tunnel in the solid wood.

It often happens that between the time of the egg-laying and the completion of the insect's development the woodman has come along and cut down the tree; the trunk has been cut up into beams or flooring planks and used in the construction of a dwelling-house. Then in due time the Horn-tail, undisturbed by any of these happenings, attempts to complete its destiny by coming forth fully winged. But the builder who used the wood for roofing beams laid upon them

sheets of lead, and these may be thought to block the Horn-tail's way. But not so; the perfect insect has jaws as good as the grub, and it makes no fuss about a sheet of lead: it eats a way through. It has even been known to eat through leaden bullets that barred the way to liberty, and has gone through a bale of woollen clothing that was in the way on another occasion.

V

UPHOLSTERERS

V

UPHOLSTERERS

There are some insects that exhibit a tendency to luxury. Many there are that finish off their cocoons with a delicate polished silken lining that the pupa shall not be in danger of injury through any roughness in its surroundings; but the select few to which we now propose to devote a few words rely not upon their own secretions for this purpose, but import hangings from without. We have already referred to the fact that *Odynerus lævipes* lines her nest in the bramble-stem with a coating of fine sand, but that is plasterer's work, and will not come under the head of upholstery.

The little solitary bees of the genus *Prosopis*, however, that excavate their nests in the stems of brambles and other plants, line the cells with a fluid from the mouth which hardens into a delicate tissue much like gold-beater's skin, but finer. There is reason for this in the fact that the provision for the food of the future grub is of a more liquid nature than is customary with the solitary bees. This usual food consists of pollen to which

sufficient honey is added to enable the bee to knead it into a pasty lump. *Prosopis* is without any pollen-collecting apparatus on the legs; and for this reason it was long suspected to be parasitical in habit. But though parasitism has been shown by Mr. R. C. L. Perkins to be indulged in by some of the numerous Hawaiian species, the charge does not lie against our native species. It is now shown that they are of rather primitive organization, and have to bring home their pollen and honey mixed—in their interiors—and regurgitate it for the storing of their cells. The mixture being more liquid in character, the cells are lined to make them waterproof for the holding of it. For the purpose of laying on this material evenly the tongue is specially developed into a somewhat triangular organ, broad in front.

In the neighbouring genus, *Colletes*, although the bees make their burrows in the ground, their cells are lined with the same material. They are less primitive than *Prosopis*, and have the legs well clothed with hairs, but they have a similar-shaped tongue and mix a good deal of honey with their pollen. They bring home a great quantity of pollen, but this is mixed with so much honey that, according to Shuckard, the mass ferments, but is nevertheless consumed by the grub without any evil results, the more liquid portion being eaten first, the more solid later.

Speaking of the upholstery work, this author says: "But the beauty with which these cells are

formed transcends conception. Each consists of a succession of layers of a membrane more delicate than the thinnest gold-beater's skin, and more lustrous than the most beautiful satin. In glitter it much resembles the trail left by the snail, and is evidently, from all experiments made, a secretion of the insect elaborated from some special food it consumes; and by means of its bilobated tongue, which it uses as a trowel, it plasters with it the sides and the bottom of the tube it has excavated to the extent necessary for one division. As this secretion dries rapidly to a membrane, it is succeeded by others, to the number of three or four, which may be separated from each other by careful manipulation. It then stores this cell, deposits the egg, and proceeds to close it with a covercle of double the number of membranes with which the sides are furnished, and continues with another in a similar manner, until it has completed sufficient to fill the tubular cavity, and, after closing the last case similarly to the rest, it stops up the orifice with grains of sand or earth."

The Carder Bee (*Anthidium manicatum*) is one of the upholsterers that go abroad for their materials, and her decoration takes more the character of tapestry. She is a larger bee than those just named, her body half an inch long, and the spread of wings an inch. She is too large for bramble-stem exploration, and does not appear to relish hard manual labour such as is involved in digging a shaft in the earth; so she looks out for the disused

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tunnel of some other insect, such as the Musk Beetle or the Goat Moth, and appropriates it to her own use.

This is the insect to which Gilbert White refers in the following passage, though he did not know its name: "There is a sort of wild bee frequenting the garden campion for the sake of its tomentum, which probably it turns to some purpose in the business of nidification. It is very pleasant to see with what address it strips off the pubes, running from the top to the bottom of a branch, and shaving it bare with the dexterity of a hoop-shaver. When it has got a bundle, almost as large as itself, it flies away, holding it secure between its chin and its fore legs."

In addition to the plant mentioned by White, the Carder Bee gathers her cotton-wool from the corn-cockle, the quince, and other plants with downy leaves and stems. With this she lines the cavity selected for her operations, and forms her cells in it, coating the inside of the cells with cement to enable them to hold the pollen-honey mixture with which she next stores them. This is the only British species, and even here it is restricted to the southern part of the Island, but there are others on the Continent. Fabre has described the work of *Anthidium diadema*, which forms its nests in hollow reeds, much after the fashion adopted by our species. The grub before pupation constructs a cocoon of its own frass connected by silk. At one end it is provided with a

perforated conical extension which Fabre surmises to be to admit air.

Anthidium septemdentatum makes its cells in an empty snail-shell, and shuts off the narrower whorls by a wall of resin collected from plants. In the remaining space which conchologists term the body-whorl she constructs a couple of cells, separated by a wall of resin, and in each stores pollen and honey with an egg. The mouth of the shell is blocked with pellets of earth, little stones, or such other material as may be handy. *A. bellicosum* has similar habits to the last-mentioned, but it does not occupy the body-whorl; in consequence it sometimes happens that a species of *Osmia* builds her nest in the mouth of a shell and blocks up the *Anthidium.* As the latter is ready to leave its cell before the *Osmia* has completed its transformations, the *Anthidium* dies a prisoner in its cell.

But the insects that are most fully entitled to the name of upholsterers are the Leaf-cutter Bees (*Megachile*). These have long been known, not only to naturalists, but also to every one who has grown roses, for every rose-garden furnishes evidence of the skill with which these bees cut out circular and oval pieces for the lining of their cells. Sometimes the foliage of one particular rose-bush is specially attacked, and the rose-grower who takes pride in the general perfection of his plants—leaf as well as flower—is rather emphatic in his denunciation of the " pest " that has wrought this havoc. All round the edges of his rose-leaves

and extending far in towards the midrib, pieces have been cleanly cut out. Where one plant has suffered almost alone in this respect, it will almost certainly be one of the varieties known as tea-roses, the firm, glossy leaf apparently being more suitable for the purpose than any other.

All the Leaf-cutter Bees, however, do not select rose-leaves for their purpose; the species that do so mostly are Willughby's Leaf-cutter (*Megachile willughbiella*) and the Patchwork Leaf-cutter (*M. centuncularis*). The first named usually makes its nests by boring deep wells in the soft wood of an old willow, and sometimes instead of rose-leaves selects those of the laburnum for its depredations. The manner in which most of the species work has been well described by Shuckard. He says:

"The cylindrical tube being prepared, which is done very similarly to the way in which it is practised by all the labouring genera, by the gradual removal of the particles of the wood, or sand, or earth of which it consists, the insect's instinct prompts it to fly forth to obtain the necessary lining, that the lateral earth may not fall in, or the wood taint the store to be accumulated for the young, for it is before this is done that the upholstery is commenced. Having fixed upon the preferred plant, rose-bush or laburnum or sallow, or whatever it may be, it alights upon the leaf, and fixing itself upon the edge, it holds it with three legs on each side; then using its mandibles as the cutter of silhouettes would his scissors, and, just

PLATE 18 THE LEAF-CUTTER BEE. Page 132

The first photo shows the female bee at work cutting an oval from a rose-leaf. The second photo is a section of an old post showing the use to which the carefully cut portions of leaves are put in the formation of the thimble-shaped cells.

Photos by H. Bastin.

PLATE 19 — A HUGE HONEYCOMB AND ITS MAKER. — Page 142

The comb from which the photograph was taken is 5 feet in its longer measurement. It constitutes the entire nest of the Dingar or Indian Honey-bee, whose portrait, one-third less than natural size, is inserted in the upper left-hand corner.

as rapidly as he cuts out a profile, does this ingenious little creature ply the tools it is furnished with by nature. The oval or semicircular cutting being thus speedily dispatched, with the legs still clinging to the surfaces, the insect biting its way backwards, the piece cut off necessarily remains within the clutch of the legs, and when about falling the rejoicing labourer expands her wings and flies off with it with a hum of delightful triumph, the cutting being carried perpendicularly to her body.

"In a direct line she wings her way to the receptacle, and arrived at the mouth of the aperture within which she has to convey it, she rolls it to its requisite tubular form and thrusts it forward to the bottom of the cavity. The first piece for the lining of the cell is always oval and larger in proportion to the succeeding ones, which, to the number of three or four, are semicircular, the first piece having an extra use to serve in forming a concave bottom to the cavity.

"Having completed the requisite manipulation for adjusting to shape the external lining of the bottom and sides of the first cell, she withdraws backwards, again flies off, and, as if she had traced a trail in the air, . . . back she wends to the same plant, and proximately to the spot of her recent triumphant exploit renews the operation, but the result of which, this time, is to be semicircular. Home she flies again, and the arrangement within of this piece is different [from] that of the first, for this is simply tubular, and so placed that it

intricates with its cut margin within the serrated edge of the first and the third, and in case of a fourth the fourth also is similarly placed, so that one laps within the other, the edges of two of these cuttings never being conterminous. The number of the cuttings is apparently regulated by the drier or moister condition of the substance in which the tunnel is drilled.

" Another duty has now to be performed, indeed, that for which all the preceding labours were undertaken—the provision for its young, wherein it perpetuates its kind. . . . Having completed the requisite store of honey mixed with pollen, this is carried to the brush with which the under side of the abdomen is furnished, by means of the posterior legs. The honey and pollen are gathered from different kinds of thistles, whence it acquires a reddish hue, and looks almost like conserve of roses, and the nest is filled with it to within a line of its top; the egg is then deposited, but the coating of leaves, which encloses the cell completely, secures the store from lateral absorption, although the mixture is rather more fluid, consisting of a relatively greater quantity of honey than is usual, excepting perhaps in the case of *Ceratina*, and although no viscous secretion is used to bind the leaves together, which retain their position from merely lateral pressure.

" The cell has now to be closed, and the artificer, knowing that the transverse section of the cell is circular, again flies forth, and without compass,

but with all the accuracy with which Leonardo da Vinci struck a circle with his pencil, to testify his mastery, cuts the leaf again in that form, and as surely: and three or four, or five or six times, repeats this operation, returning each time with each piece, so many having been variously observed. The separation between the cells being thus consolidated, it is further thickened by the lateral, spare, protruding edge of the leaf first introduced lapping over it."

In the same manner other cells, to the number of four or five, are formed above the first, and any space remaining in the tube is filled up with earth. The bee then bores another tube, and repeats the process until her eggs are exhausted. When the larva has consumed its food-store it spins a lustrous silken cocoon attached to the hangings of its cells, and undergoes the changes into chrysalis and perfect bee.

Our other native species proceed in a similar manner, though some of them work in different materials. Thus *M. circumcincta* makes her excavations in the ground of banks, but lines them with rose-leaves; *M. argentata* mines in sand, and sometimes uses the leaves of the bird's-foot trefoil (*Lotus corniculatus*) for her cells; *M. ligneseca*, like *M. willughbiella* and *M. centuncularis*, make theirs usually in wood, and *M. versicolor* has been found nesting in the stumps of broom (*Sarothamnus scoparius*). *M. centuncularis* again has sometimes been found to use the *petals* of the garden geranium

for her upholstery; in which she appears to come close to the European species, *Osmia papaveris* (formerly included in this genus), which lines her cells with the petals of the Corn Poppy (*Popaver rhœas*).

M. albocincta usually appropriates a burrow of the earthworm, and as this is far too long for her purpose, she stops it at the proper depth by a plug of leaves on which she builds up her cells. Other species are fully alive to the labour saving effected by adapting a previously existing cylindrical hole for their nesting-place. Bamboos used for the support of tall plants in gardens are frequently taken by them; screw-holes, pipes of small bore, and gun-barrels also come handy.

Osmia papaveris, to which we have already briefly referred, is usually found in the neighbourhood of corn-fields, and sinks its shafts in the firm earth of roads and well-trodden footpaths. Cutting semi-circular pieces from the bright-red petals of the poppy, it uses them in much the same manner as *Megachile* does with her leaves; but instead of cutting small circles for capping the cells, she turns over the upper edges of the lining pieces to effect the closure.

VI

WAX-WORKERS

VI

WAX-WORKERS

The workers in wax are not a numerous company, so far as species are concerned; but being social insects they form communities that more than make up for paucity of species by the abundance of individuals. These communities are also continuous. With the Masons, the Miners, and the Carpenters, the clever work they have done ceases to be useful after one season's use. The insects themselves are but annuals. The workers in wax, on the other hand, are perennial—that is to say as communities; the workers themselves, other than the queen, or egg-laying female, are no longer lived than their solitary relations. A wild community of Honey Bees in a cave might go on for ever.

The huge difference in the two groups—social and solitary—that this implies has been brought about solely by the discovery of the socials that if they retained honey in their stomachs their vital chemistry would convert it into wax. But for this discovery the Honey Bee would probably never have figured largely in human literature as she has

done, whilst her solitary relatives, equally industrious, no less solicitous for the interests of an unseen progeny and the continuance of the race, have been utterly ignored save by a handful of naturalists. But for this discovery man would never have found the bee worth eulogizing or robbing—and the eulogies have been directed mainly to her habit of storing up honey which man could appropriate to his own use. The discovery of the secret of wax-production and the acquisition of the knowledge of its ductibility and application to the use of the community have made all the difference to the Honey Bee, and—*inter alia*—have brought her completely under the subjection of man.

Wax is a costly substance to produce, from sixteen to twenty pounds of honey being consumed to make one pound of wax. It is made available for use by its secretion by glands on the surface of the rings on the under side of the hind body. Here it appears as thin scales which are removed by the bee's hind legs and passed to the mouth, where the wax is worked up—possibly with the addition of saliva—into a condition suitable for the use of those who have to build up the comb and model the six-sided cells. But before we look further into the economy of the domesticated Honey Bee (*Apis mellifica*), let us glance at the wild honey-storing bees.

In tropical countries there are several species of wild Honey Bees (*Melipona*) which make their

nests in trees, caves, and buildings, in the latter case often becoming a nuisance. We have already mentioned the Brazilian species that gather clay at times instead of pollen, for the purpose of filling up inconvenient crevices in the hollow tree they have adopted as a "hive." Bates says that most of the South American species of *Melipona* are workers in clay as well as in wax, and they appear to use it as our bee uses propolis, the gummy varnish scraped from the leaf-buds of certain trees and the stems of some smaller plants. The same naturalist states that none of these American bees have attained to that high degree of architectural skill in the construction of their comb which is shown by the European hive bee. The wax cells of the *Meliponæ* are generally oblong, showing only an approximation to the hexagonal shape in places where several of them are built in contact.

These bees though they have stings cannot use them—at least on human skin—because their points are not sharp enough, but they make up for this defect with their jaws when any one disturbs their nests. The Indians, of course, frequently do this to obtain honey, which the nests contain in abundance. Bates saw one opened which contained a couple of quarts of pleasantly tasted liquid honey, and the Indian who obtained it was completely covered with the bees. Gosse describes one of these "stingless" bees, known in Jamaica as Angelitos for this reason. He says that they keep their store of honey in the lower

part of the nest, away from the brood-cells, in a cluster of cups as large as pigeon's eggs.

The Dingar or Big Bee (*Apis dorsata*) of India differs from these *Meliponas* in the fact that its sting has a very fine and practicable point, and the bee is always ready to use it. It would certainly have no chance of earning an Indian name equivalent to Angelito; and it is execrated by archæologists on account of its reprehensible habit of attaching its enormous combs to fine buildings like the Taj Mahal at Agra, and the paintings and sculptures in the rock temples at Ajanta. It also attaches its combs to the under side of the horizontal branches of tall trees, such as the cotton tree (*Bombax*).

These combs, according to Mr. E. P. Stebbing, are semi-elliptical in shape, five feet long and two and a half feet in breadth. A single tree may have a dozen of these huge combs on its branches; and woe to the newly arrived and innocent European sportsman who "between beats" indulges in a restful pipe under one of these trees. The ascending reek of burnt tobacco will excite the bees to fury, and they will descend in thousands, and cause the valiant sportsmen—probably brave military officers—to beat an ignominious retreat at a speed unusual in that climate. One well-known archæologist who was investigating the mural art of Ajanta had to remain in the river for hours, up to his chin in water, to escape the fury of the resentful bees he had disturbed. In Murray's

Handbook for India, travellers visiting the caves of Ellora and Ajanta are advised to supply themselves with "a pair of stout leather gauntlets coming up above the wrist half-way to the elbow, and a light wire-mask with a back-piece to protect the back of the head and neck, many persons having been so badly stung that in some cases death has ensued." Attempts have been made to domesticate the Dingar, but they have failed.

So extensive a literature exists upon the Honey Bee (*Apis mellifica*) that it would be idle to attempt to enter into details of its economy here; we will only deal with it as a wax-worker.

The production of this wax by the worker bees does not go on whilst they are out collecting honey or pollen, or whilst they are attending to the brood in the hive. It is a distinct employment, and a number of workers appear to be temporarily charged with this function apart from other duties, and it takes them twenty-four hours to produce the plates of crude wax. A peculiar rite appears to be essential for the carrying out of this wax production, though why it is necessary is not evident. The bees have to hang in festoons attached to each other by the feet only. When wax is needed these festoons hang from the roof of the hive wherever there is room for them.

A festoon is formed in this wise: a couple of bees station themselves apart, each clinging to the roof by its fore feet only; another bee will, with its fore claws, cling to the hind claws of the first

one, and so on in the same manner until two hanging chains of bees are formed. Then the two bottom ones cause the chains to swing until they can hook their hinder feet together to form a festoon. So they hang for about twenty-four hours, when the festoon breaks up and the bees which composed it resort to the cell-makers and supply them with the material for their work.

When the wax-secreting worker has brought the thin plates from the abdominal rings to her jaws and manipulated them into true bee's-wax as we know it, it issues from the mouth as a thin strip which is brought to the cell-makers and applied by them to the walls of the cells now under construction, a work that is carried on with great rapidity.

A considerable amount of honey is converted into only a small quantity of wax, and therefore the workers use it with parsimony. There is no waste, and they have learned to make the maximum structure out of the minimum of material. That is the reason for the six-sided shape of the cell. All the solitary bees, as we have shown, make their burrows cylindrical, based upon the form of their bodies, or at least of the body revolved on its own axis, as they have to revolve in finishing off their excavation.

Now, though the hexagonal cell admirably fits the cylindrical body of the bee-grub, it cannot be modelled upon the body of the worker bee. If the individual cells of the bee-comb were fashioned

separately, and then a number of them were brought together, under equal pressure they would form hexagons; but they are not made separately, but are built in mass, and every part of the walls of one cell forms part of the wall of a neighbouring cell. This is even so with the base of the cell, which forms part of the base of three other cells on the other side of the comb. To human artificers the task would necessitate a resort to mathematics, but the worker bee issues from the chrysalis fully competent to undertake the task without swallowing the books of Euclid, and without even parental instruction. Pure "rule of thumb" practice, but even so the mathematicians have failed to find any flaw in its results; indeed, there is a well-known record of a mathematician's work being corrected in a sense by the bees.

Maraldi, a famous mathematician in the early part of the eighteenth century, took an interest in bees, and invented a glass hive in order to observe them at work. He found that the bottoms of the cells formed an inverted pyramid and that they were hexagonal like the walls, but formed of three lozenge-shaped plates. His mathematical mind was curious to know if the bees were mathematicians also, so accurate did the work appear to the eye. So with great care he measured the angles of these lozenges, and found that the greater angles were 109° 28′, and the lesser ones 70° 32′.

Réaumur, who knew of Maraldi's calculations, and suspected that such precision on the part of

the bee had relation to the desire for economy in the use of the precious wax, thought to test the matter from that point of view by propounding this problem to König, a noted geometrician: "What should be the angles of a hexagonal cell with a pyramidal bottom formed of three similar and equal rhomboid plates, so that the least matter possible might enter into its construction?" M. König, it should be explained, knew nothing of Maraldi's measurements. König employed the infinitesimal calculus, and found that the great angles of the rhombs should be 109° 26′ and the small angles 70° 34′. Here was a surprising agreement between theory and practice!

There for a time the matter rested, and then Maclaurin, the Scots mathematician, took a turn at the problem propounded to König by Réaumur. The result he arrived at agreed precisely with the measurements of Maraldi; and it was then endeavoured to discover how König had made the mistake. It was found that the book of logarithms he had used as the basis for his calculations contained an error which accounted for that difference of 2′ in his results. So the bees led to the correction of the book of logarithms, whose error might have led in other directions to lamentable results.

The comb is not built upwards from the base but downwards from the roof. A small quantity of wax is deposited by one bee, to which others add in succession until sufficient is amassed for the

PLATE 20 HONEY-BEES COMB-BUILDING Page 146

The comb is built from above downwards. The bees on the lower edge are constructing new cells; those above are finishing off the margins of the cells and making the surface of the comb even.

Photo by Tickner Edwardes.

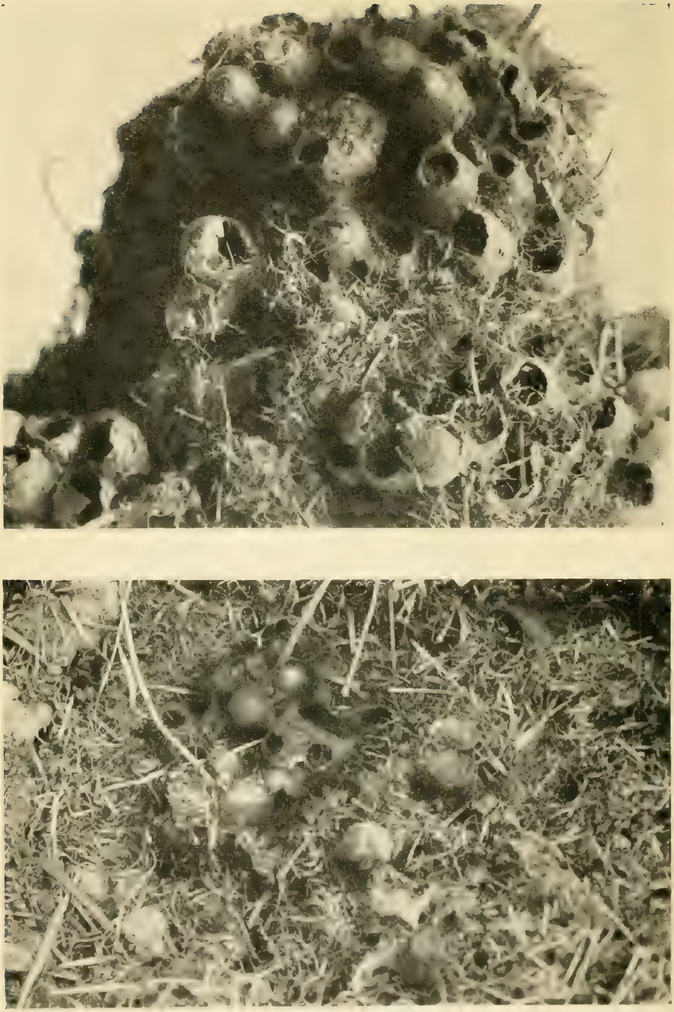

PLATE 21 HUMBLE-BEES' NEST. Page 154

The lower photo shows a ground built nest with the dome of shredded grass and moss removed. In the upper photo a cluster of cells, mostly vacated, have been taken from their surroundings.

Photos by Author.

commencement of operations. Then a bee begins to excavate in it the foundation of a cell. She works for a time, and then goes off, another worker taking her place immediately and working for a spell. No one bee, therefore, completes a cell, but each is built up by a number of workers doing a little in succession. When the bottom begins to take form, other bees work at a corresponding cell on the other side of the wax wall. It will be seen that these three lozenge-shaped plates constituting the bottom of the cell have each two free margins—six in all—and it is by building up the walls from these margins that the hexagonal form of the cell is arrived at. As the work of the builders proceeds, the workers who are making wax come and go, leaving additional contributions of wax for the builders to manipulate.

There is a difference in the size of the cells according to the use to which they are to be put. Some of the earlier observers, noticing this discrepancy in size, regarded it as a defect in the calculations of the bees. As a matter of fact the difference is deliberately designed. The cells intended as cradles for worker grubs have a diameter of one-fifth of an inch; those for males or drones are a quarter of an inch; the royal cells for the production of future queens are different altogether from these, much larger and of different form, jutting out from the comb and taking a downward direction. They are somewhat pear-shaped, and about five times larger than the drone cells. There

is no evidence of parsimony in the construction of the royal cell; the precious wax is lavished here to form thick walls, rough and irregular without, but smooth and polished within.

We have spoken of the economy shown in building the ordinary cells. The walls are so thin that light passes through them, but those of the queen cells are quite opaque. The outer edge of the ordinary cell is thickened into a sort of rim, as this has to be subjected to much friction from the feet of the workers frequently passing over it, whilst the lower parts of the walls are supported by the mutual pressure of the honey in adjacent cells. Roughly speaking, these cells may be said to be horizontal, but there is a slight inclination downward from the mouth to the base. Although the cells are in this position, honey does not run out, chiefly owing to capillary attraction, though it might do so in very hot weather when the honey becomes more fluid. Until a cell is quite full of honey it cannot be capped, and it will be easily understood that an enormous number of journeys is required before the little workers can bring home sufficient honey to fill one cell.

To prevent running, the workers have resort to an ingenious device: they obtain a little honey from one of their first-filled cells which is of a firmer, denser character, owing to evaporation, and this is made to float upon the new honey. In places remote from a proper water-supply system, where the water for domestic use has to be

brought from spring or well, this is usually done by means of a couple of pails and a yoke. To guard against spilling by the way a flat piece of wood floats upon the top of the water in each pail. The disc of firmer honey serves a similar purpose in the honey cell.

When the cell is full the workers cap it with a thin sheet of wax attached to the edges. In other cells pollen is stored up for the sustenance of the grubs, the workers as they return from excursions among the flowers simply dropping their collections into the cells and leaving those that are on indoor duty to pack it.

When the brood cells are ready the mother bee (usually styled the queen) traverses the comb, and lays an egg in each cell. She appears to know what is the character of each egg before she deposits it. The first few may be deposited in the drone cells, then a vast number is laid in the worker cells. The eggs of the two kinds differ in size, just as the cells do. In April and May she will lay eggs at the rate of fifteen hundred to two thousand a week, and continue doing so. In six weeks she has furnished ten or twelve thousand cells with occupants, and during the whole of one season will lay thirty or forty thousand eggs. During her life she may produce as many as a hundred thousand.

The eggs hatch after three days, and the minute grubs are at once tended by the nurse bees, who feed them with bee bread, which is a compound of pollen and honey. On this diet the grub thrives

and when only five days old it is full-fed and fills the cell. The nurse bees then close the cell with a cap made of wax and pollen, which is porous and admits the air. The grub then spins its cocoon, and changes into the chrysalis condition. About a fortnight later it appears as a winged worker, and rests for half a day to allow its integuments to harden, after which it is ready to take up duty as a nurse or other indoor worker. The evolution of the drone follows much the same course, but, so far as information goes, when it emerges as a bee, bigger than a worker and with compound eyes that meet on the top of the head, it does no work beyond taking part in the ventilation of the hive by fanning with its wings.

The "royal" cells are mere cups when the eggs are laid in them. In three days also these are hatched, and the nurse bees drench the young grub with a special food, the "royal jelly." As the grub grows, the cell walls are built up, and in five days full growth is completed, when the cell is finished and sealed up for a fortnight, by which time the female bee issues from her chrysalis skin, and is soon ready if need be to accompany a swarm to found a new colony. Or she may be killed before emergence by her jealous mother.

Whilst on the subject of wax we ought to mention that for less important uses, such as stopping cracks, or sealing up the bodies of invaders whom they have killed but cannot remove, they use a substance to which the ancients gave the name

of propolis. This is the gummy secretion gathered from the leaf-buds of poplars, horse-chestnut, pines, and the stems of other plants. They take it home as they do pollen, in the baskets on their hind legs; but they cannot discharge their loads of propolis as they do their pollen: it is so sticky that it has to be pulled off by other workers.

Other wax workers will be found in the Humble or Bumble Bees (*Bombus*), which are also social, the community again consisting of workers or incomplete females, drones, and one or more perfect females. As compared with the Honey Bee the Humble Bee is a burly giant, whose re-appearance in spring is always welcomed as she goes about the earliest blossoms and lets the world know by her cheerful humming that she is returning to activity. These early bees are always females that have lain in a torpid state through the winter in some cosy nook, and have temporarily emerged for the refreshment that sallow catkins afford.

But the Humble Bee community is a very small affair in comparison with that of the Honey Bee. As you stand under a sallow-tree in March and listen to the organ-like volume of music that emanates from the hundreds of Humble Bees that are gathering nectar from the flowers—the so-called "palm"—you may be excused for regarding them as a "swarm" akin to the swarms of Honey Bees. As a matter of fact, every individual of that host is an independent female, each the possible founder of a new and separate colony. When they have

filled their honey-bags, each goes back to her hibernaculum to sleep again until May. Then she looks about for a deserted mouse-nest or other suitable retreat, and lays the foundations of her colony that is to be. This may be either on the surface protected by grass, or underground at the end of a tunnel—often a yard long. Different species have their own special tastes in this matter.

The Humble Bees are not nearly so eminent as wax-workers as are their cousins of the hive, for they build no proper combs. They produce little wax, and that exudes from under the rings on the back, not from the under surface as in the Honey Bee. The wax, too, is brown in colour, and much softer than that of the Honey Bee.

It is the custom to speak of the fertile female Humble Bee as a queen just as one speaks of her equivalent in the hive; but there is a great difference between them. The queen bee is a mere layer of unlimited eggs: she is too regal to be domestic. We prefer to speak of the founder of the Humble Bee colony by the higher title of mother bee. She is a real mother with the maternal instincts highly developed. Unaided, she lays the foundations of the family, incubates her eggs, nestles and feeds her brood, and when she has reared a bevy of infertile daughters to help her she still takes part in all this work so long as her physical powers allow her to do so.

Having selected a suitable site, she sets to work to prepare the nest. If it is an abandoned nest

of the field mouse, she probably finds it already provided with material suited for her use. This will consist of half-rotted grass, finely divided and cut into short lengths. The mouse is very particular in the selection of material, taking the withered blades from the base of a tussock and dividing them lengthwise as well as cross-wise in order to have them perfectly ductile and capable of felting. This also is the quality of material the Humble Bee likes. Sometimes she mixes fragments of fine moss with it, probably to increase its springiness. All this material is taken, bit by bit, in her jaws, passed by her two hinder pairs of legs under her body and accumulated behind her. Then she pierces a tunnel to its centre, where she hollows out a small oval chamber. Her home is ready for furnishing.

She next sets off on a hunt among the flowers, and comes back a little later with her thighs bulging with masses of pollen and her honey-crop filled with nectar. She brushes off the pollen in a little heap upon the floor of her nest and moistens it with honey; then with her jaws kneads it into a paste which she builds up into a solid mass. Upon this she constructs a ring-like wall of wax—her first cell, of which the pollen mass forms the floor. In this cell she lays about a dozen eggs, and then closes in the top with a dome of wax. She also constructs a pot of thin wax to contain honey, which is placed in the doorway of the nest-chamber and filled with honey. The honey-pot is about

half an inch across and about three-quarters of an inch deep. This filled, she is ready for the possible advent of a bad day when she cannot steal a few minutes from her nursing duties to fly to the nearest flowers and obtain food.

She now takes up her station over her cell, with her face to the door, and actually incubates her eggs. The grubs hatch out on the fourth day, and set to work feeding upon the floor of the cell. Each scoops out for itself a hollow in the pollen-mass, and so that they shall not cut through it to the exterior the mother bee collects more pollen and plasters it all around the original heap. She also makes a semi-fluid mess of pollen and honey, and cutting a hole in the wax lid drops the mixture in upon the grubs.

Between these necessary expeditions for collecting food she sits upon the brood mass, from which she can reach with her long tongue to the honey-pot at such times as she requires food for herself. Much of this is used up in the production of heat to keep up the temperature of the nest night and day. The honey-pot is always undergoing changes when it is in use. When full it is relatively tall and has a small mouth. As the honey gets low so do the walls of the pot in agreement, and when it is refilled the walls are built up again. But after about a month, when there are workers about to assist the mother, the waxen pot is neglected and falls into ruin. The honey is of a more fluid character than that stored by the Honey Bee.

The legless larvæ when they are about five days old increase the size of the hollows in which they repose, each occupying its own cell in the pollen mass, and two days later spinning a tough papery cocoon. The mother about this time clears away the brown wax she has been continually adding to for the protection of the grubs, and reveals the upper ends of all these cocoons standing side by side. A depression runs through the middle of the group which indicates where the mother's body has lain in her brooding vigils. This groove she still continues to occupy, for her offspring still need warmth to help their development even when they have changed into chrysalides.

On the twenty-second or twenty-third day after the eggs were laid she has the reward for all her labour, for the chrysalides develop into bees and begin to bite through the tops of the cocoons and emerge. In this they are assisted by the mother, who enlarges the openings to make their exit easier. The newly emerged bees are all small workers, and as soon as their legs and wings have become firm and their wetted matted coats are dry, they begin to assist the mother in collecting provisions for their larval sisters. For all this time the mother bee has been making other cells and filling them with eggs, so that the broods come on with intervals of only two or three days between them.

The new workers start collecting out-of-doors when only three or four days old, and do their

work at once as though they had been trained to it. Every few days they are joined by later emergences—all workers for a time. Later the mother lays eggs which produce males and females. The cells for the second and later batches of eggs are built on the sides of the taller cocoons, so that they can derive warmth from the mother's body as she is imparting it to her first brood. It is to this arrangement that the higgledy-piggledy appearance of the nest at the end of the season is due.

Later in the season when the mother bee is getting enfeebled the older workers take to laying virgin eggs, but these only produce males. The sexual bees produced by the mother earlier in the season are all much smaller than those produced in early autumn, upon which the continuance of the race depends. For the Humble Bee communities all come to an end before winter, and the future of the species depends upon the young fertile females who go into hibernation, and are ready to begin egg-laying in spring.

These Humble Bees, of which there are many species—seventeen of them natives of our own Islands—differ in their nesting habits, some, as indicated, going underground, whilst a few, known as Carder Bees, form their nests in slight hollows of the surface, covering them with domes of felted moss and grass. These Carders are much less numerous in individuals than the subterranean builders. Smith says that the communities of

Bombus terrestris—an underground builder—are the most numerous. One such nest he found to contain 107 males, 560 females, and 180 workers; a surface builder's nest—of *Bombus sylvarum* or *B. agrorum*—would contain about half these numbers of inmates.

The empty cocoons from which came the first batch of workers are utilized by them for the storage of pollen, and by some species as honey-pots for the immediate use of the commonwealth. We have mentioned the readiness of the underground builders to adapt a mouse's nest and run to their own purposes; and the surface builders are not above similar economy of labour. We have found them making use of a field vole's nest. They are not likely to take possession of such places before they have been abandoned by the original owners, for mice are great enemies to the brood, though they know better than to make an attack when the bees are at home.

Smith has recorded an instance of *Bombus agrorum* taking possession of a wren's nest that was occupied by a clutch of the bird's eggs. Possibly the bee thought they were cocoons; anyway, she heaped up her collected pollen among them, and so disgusted the wren by her action that she abandoned her eggs, and it is probable built a new nest elsewhere. Mr. Sladen mentions a double case of adaptation. A mouse had utilized a cast-off shoe as a nesting-place, and after the mouse had done with it *B. agrorum* adapted the mouse-nest

to her use. Such a course of procedure saves the colony-founding female the labour of collecting all the material required, and enables her to devote her energies at once to the laying of eggs and gathering food.

VII

PAPER-MAKERS

VII

PAPER-MAKERS

The ancient Egyptians are generally given the credit for the invention of paper from slices of the stem of papyrus reed, but probably the Chinese would claim that they made it from another plant. Neither race has the slightest claim to be considered as the inventors of paper, for the wasps were probably busy manufacturing paper long before the first man put in an appearance on the face of the earth.

Not so long ago nearly all paper turned out by our paper-mills was made of rags; but the demands for paper have long outgrown the supply of rags, and we have now to cut down the primeval forests, reduce the wood to pulp, and use the crushed fibres to make most of our paper. In this "up-to-date" development of an important industry we are merely going back to the primitive craft of the wasps. Of course, we have improved upon their methods, bringing in wonderful and expensive machinery for pulping the wood and converting it into smooth sheets of varying thickness. The wasp does the whole business with her mandibles and tongue.

It will be objected, of course, that the wasp's paper is of a very inferior quality and not durable; but the wasp makes the sort of paper that she requires, just as we do. We require fine writing-paper, printing-paper, packing-papers of various degrees of coarseness, blotting-paper, etc., and we make what we require. If the wasp is going to use her paper where it will have protection from the elements she makes it friable. If it is to stand rain and wind she makes it stronger.

The wasps' nests we are acquainted with in this country are intended to last a few months only: it would be unfair to accuse her of making temporary material where she does not require permanence. Besides, where occasion requires it the wasp can make tolerably permanent structures of fine card or *papier mâché* that is waterproof and upon which a man can write with a pen. What more can be expected of the wasp as a paper-maker than this? If she makes materials that suffice for her needs, she does as much as man does for himself. The only difference is that man is never satisfied, but ever wanting something more than his actual necessity demands.

Like the Honey Bee the Social Wasps (*Vespa*) are mathematicians. They build their combs with a strict eye to economy of material, and they have adopted the hexagon as best serving this end. But the wasp combs are all single. They have not learned that there is additional economy in building them back to back. Their combs are also built

horizontally with the cells opening downwards. Like the bee, they begin their building at the top of their nest and work downward, but there is this difference, that the bee-comb is attached by its double thickness and each one has its own support; the single flimsy combs of the wasp are suspended by paper pillars, the first layer to a branch or underground root, and each succeeding comb to the one previously constructed; so that the entire series of combs has to depend upon the original pillar.

In a previous chapter we have referred to the idea, still entertained by a few, that the hexagonal form of the bee cells is due to mutual pressure. In the analogous case of the wasp, where the same shape is adopted, observation of the building-up of the comb convinced us many years ago that the hexagon is built as such, and not produced by pressure. There is this difference, however, between the cell of bee and wasp—the latter has a base slightly convex on the exterior, and the interior forming a broad inverted cone. This is due to the fact that there is no economy possible in adopting the three rhombs of the bee cell. The upper side of the comb is flat as a whole, but the slight convexity of each cell is patent to the eye, and it is equally evident that the hexagonal form is adopted from the beginning.

Whence comes the material of the comb? The wasp cannot produce paper pulp from the plates of her abdomen as the bee produces wax. It is

frequently asserted that she resorts to rotten posts and stumps for her material; but though this may be true of the hornet, it is not true of the wasp. She uses perfectly sound wood, though she undoubtedly prefers wood that has been "seasoned" by exposure in a cut state to growing timber. We have a garden fence that is a favourite quarry for the raw material of wasps' nests. In the busy season you may see scores of worker wasps upon it shaving off delicate films of its surface, reducing it to pulp, and flying off to their nest with a pellet of it. The greater portion of the fence is of oak, but a smaller length is of pine; and they take from both. The pine must be the easier to work, and one would expect them to restrict their attentions to it; but they do not. It is probable that they may have different uses for the two sorts of material. The photograph of a few inches of the pine fence will make clear the extent of surface shaved at each operation. The average width of a shaved space is two millimetres, and its length about ten millimetres, some longer, some shorter.

Arrived at the nest, the worker flies to that part where material may be most in request at the moment, and chewing up her pellet afresh, she mixes it with a gummy secretion from the glands of her mouth, and then proceeds to spread it out thinly as an addition to the edge of work in progress, whether it be a new layer of the outer walls or the lengthening of brood cells to make them agree with the increasing length of growing grubs.

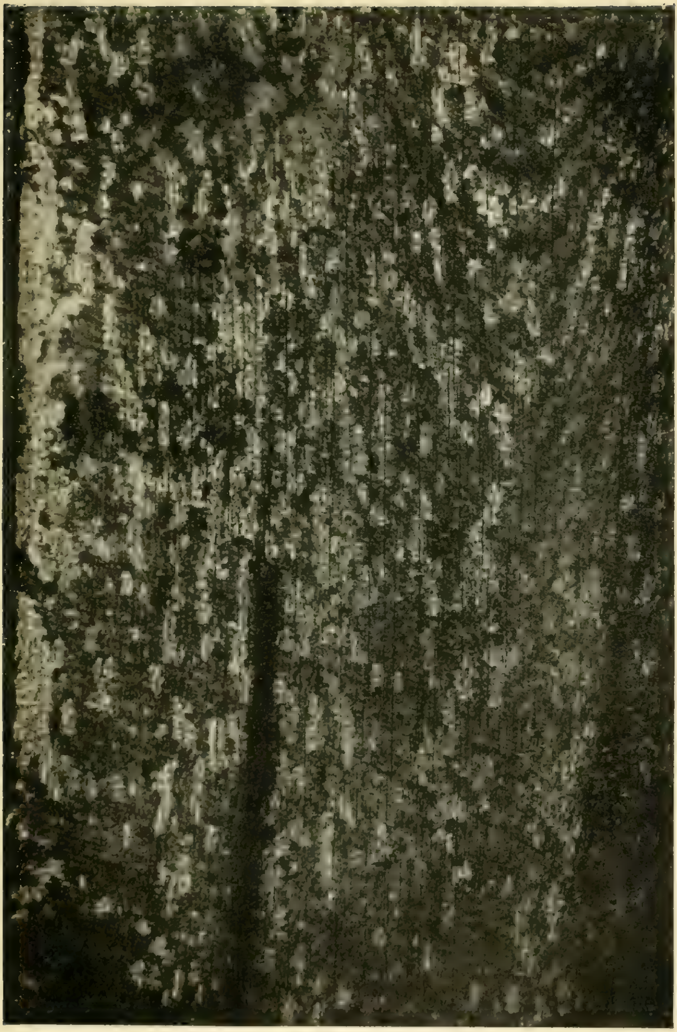

PLATE 22 THE RAW MATERIAL OF WASP-PAPER. Page 164

The wasp was the inventor of wood pulp paper. The photo shows a portion of a fence whose face has been regularly shaved by wasps to yield them the material for constructing their nests and combs.

Photo by Author.

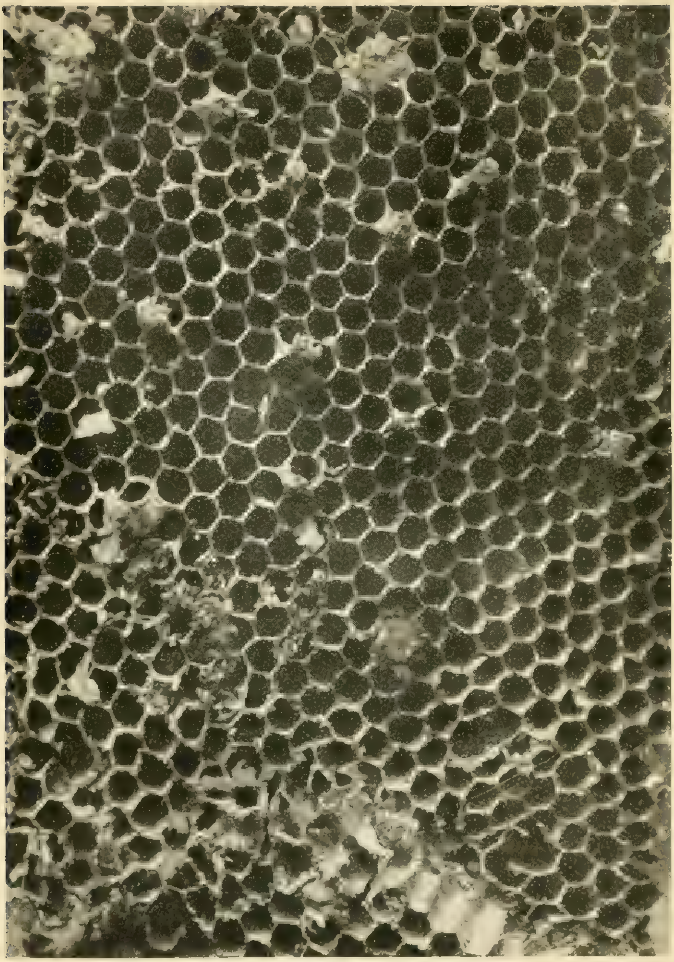

PLATE 23 COMB OF WASP. Page 168

The material taken from the fence shown in the previous plate has here been worked up into a coarse paper which has been used in the construction of thousands of six-sided cells.

Photo by Author.

Although the cells when once advanced to their full size demand no paper-making, and serve for the accommodation of successive batches of grubs, there are always new combs to be built and the circumference of old combs to be increased by adding new cells to their edges. In addition, with this growth in the size of the combs, and the provision of new ones below the old, the area of the nest has to be increased, and this requires more and more paper; so that until quite late in the season our fence is in constant request. There are some people so biased against the wasp that, if they were only sufficiently observant to see this continual shaving of their fences, they would make this a fresh count in the indictment against her.

At first the wasp nest is a very poor affair. The so-called "queen" or mother wasp, that has passed the winter in a torpid state where she has been protected from frost, begins afresh in the early days of spring. She only emerged from her pupa-cell at the fag end of last season, and after her marriage flight went into retirement. So she has had no opportunity for acquiring experience by watching the procedure of her mother or her older sisters. Her mother had probably died of old age and egg-bearing before the daughter threw off her pupa-skin.

However, she knows that it devolves upon her to make provision for her coming offspring, and her first concern is to find a reliable source for her raw material. That having been discovered and its

position committed to memory, her next task is to find a suitable building site. Her choice will depend upon whether she is a Tree Wasp or a Ground Wasp. We have eight British species of wasp. Of these the largest is the Hornet (*Vespa crabro*), which builds in hollow trees and under thatched roofs; another, the Austrian Wasp (*Vespa austriaca*) is a lodger in the nests of other wasps. Of the other six, three (*V. arborea*, *V. sylvestris*, and *V. norvegica*) build in trees and bushes, and the remaining three (*V. vulgaris*, *V. germanica*, and *V. rufa*) make their nests underground, often in the nests or runs of mice or moles.

Supposing she was one of the Tree Wasps, she would probably select a branch of a holly-tree, a larch, or a gooseberry-bush. After careful examination of several branches, as though she were considering their strength, their sunny aspect, shelter from gales, and so forth, she flies to the fence previously discovered and scrapes off a ball of woody fibres, with which she returns to the tree. Masticating her material and thoroughly incorporating with it the fluid cement from her mouth, she next spreads it out around the branch. Making repeated journeys to her timber stock, she soon has a short bar of *papier mâché* hanging straight down from the branch. To the free end of this additional paper is attached, which takes the form of three saucer-like shallow cells. As soon as these are ready, she lays an egg in each, gluing it to the sides, for the cells, be it remembered, are inverted, and

but for this precaution the eggs would fall out. These soon hatch, but the minute grub does not cast off the whole of the egg-shell: it keeps the hinder portion of its body in the base of the egg-shell until its final cast of skin, and by this means retains its hold of the cell.

Until the eggs hatch the mother wasp is free to extend her home. She builds a paper umbrella over her three-celled comb; she adds other cells to the first three; she encloses the comb in a pear-shaped bag with an entrance at the narrow lower end. When the eggs are hatched two or three days later she has to provide the grubs with food continuously, and she does this by capturing flies and other insects, masticating the soft parts and feeding the grubs from mouth to mouth, much as a bird feeds her callow nestlings. With such care and attention the grubs grow rapidly, and in between her food-finding excursions she has to find time to visit the fence, to get more wood raspings with which to increase the depth of the cells. If you look at a piece of wasp-comb you can trace the growth of the cell-wall by the lines of slightly varying colour.

When the grub has reached its full dimensions it spins a silken cap over the mouth of the cell, and continues the silken layer down to the bottom of its cell. This is its cocoon. The upper part is of the same close texture as the cap, but lower down it becomes much thinner. In this cocoon the grub changes to a chrysalis, and after a rest of

a few days emerges as a worker wasp and eats through the cap of its cell. All the earlier cells produce workers, and these, as soon as their yellow-and-black armour has set firm, begin to help the mother wasp. They gather wood-fibres, and build new combs; cut away the old walls to accommodate an increased diameter of the combs, but first build newer walls farther out.

The mother wasp can now devote her energies to laying eggs in the new cells, the workers performing her other functions as nurse and builder. For a long time the combs produce nothing but workers, so that when two or three batches of these have emerged, the work of extension goes on with rapidity. The old cells are cleaned out and made available for a fresh batch of eggs in addition to those laid in the new combs. Later in the season cells of rather larger size are constructed, and from the grubs reared in these larger wasps emerge. These are males and females.

It is not generally understood by those who have not made a study of insect life that there is no possibility of being stung by a male wasp, for the simple reason that he is not endowed with a sting. But, of course, those which usually cause alarm by their presence have the power of stinging, they being nearly always workers, the males, as stated, being produced only late in the season and dying soon after mating. The armed workers, however, should not be feared, for they have scarcely ever been known to sting unless they are molested. A

worker may alight on your hand and walk leisurely over it, but will not sting unless some nervous movement be made which alarms the wasp.

We know that every man's hand is against the wasp, and we imagine, therefore, that the wasp is against every human being. The truth is that the wasp is, from the human viewpoint, one of the most useful and harmless of insects—spoiled plums notwithstanding. The one great defect of the wasp is that it does not store up honey or wax that could be raided by man and turned to a profit expressed in £ *s. d.* The unceasing good the wasp does to man all the summer by destroying millions of his insect foes does not count. The eyes of the husbandman are blinded by ancient prejudice, and he cannot distinguish between friends and foes. We think it is extremely probable that if a hive of honey bees and a nest of wasps could be put in the opposite scales in which human interests are weighed, it would be found that they were pretty level.

We have said little about the paper walls of the wasp's nest, but it is important that they should be described. Wasps, like bees and many other highly organized insects, are very susceptible to cold, and for the proper development of their young it is necessary that their nests should be kept at a moderately high temperature. The presence of thousands of workers in a large nest secures this, and movement of the air and ventilation are effected by the vibration of innumerable wings.

The warm air is kept in by the paper walls, and radiation on cold nights is guarded against by the method of construction. The principle of the down quilt and the woollen blanket had been discovered by the wasp long before man adopted these substitutes for the furry coats of the animals he used to hunt.

If you cut through the walls of a large wasp's nest you will find there are several layers of paper with air spaces between them. Imprisoned air between layers of non-conducting material is one of the most efficient means of maintaining an equal temperature; and the building of the vespiary walls is evidently carried out with this principle in view.

In the early days of a Tree Wasp's nest, the umbrella that is built as a shelter for the first three or four cells is soon continued downwards as a pear-shaped bottle with a mouth at the narrow end. When a few workers are available they cover this with additional wrappings, always with a space between every two layers; and right through the season they are always adding more and more to the exterior. If one could judge only by what is seen from outside, he would imagine that the walls had become excessively thick; but all the time that additions are being made to the exterior the inner layers are being successively cut away to allow of additions to the circumference of the combs. In this way the nest is being constantly enlarged without at any time exposing the interior.

There is considerable difference in the paper made by the various species of wasps. That of the Tree Wasps is smoother and much more regular in its surface than that of the underground species, which is made in semicircular lines which give it ruggedness and inequality. One would almost expect that an underground nest, being protected all around by earthen walls, would not be furnished by paper walls in addition. But they are apparently necessary to equalize temperature as well as to keep off emanations of damp from the soil and the percolation of rain through the roof of the cavern.

A good idea of the industry and the numbers of a colony of wasps can be gained by sitting down near the entrance to one of these subterranean nests and noting the exits and entrances of the workers. There is always sufficient room in these passages to allow wasps going in opposite directions to pass each other without any danger of jostling. Mr. and Mrs. Peckham, in giving the results of some observations they conducted in this way say:

"Experiments that would have been dangerous to life and limb had we tried them with a paper nest hanging in the open, were easy here, so long as we kept calm and unflurried. Intent upon their own affairs, and unsuspicious of evil, perhaps because they knew themselves to be armed against aggression, they accepted our presence, at first with indifference; but as we sat there day after day we must have become landmarks to them, and

perhaps before the summer was over they considered us really a part of home."

This seems to imply that the Tree Wasps would not have regarded their espionage so complacently; but, whatever may be the case with American wasps, we can testify that our *Vespa norvegica* is quite as tolerant or indifferent as a Ground Wasp. All one summer we had such a nest in our garden and saw it grow from a diameter of two and a half inches to one of over six inches. We were not able to station ourselves by it for a day, but at odd times as occasion offered we would stand for an hour at a time with our face only a few inches from its doorway, and although we were in the line of approach for many wasps, we were never molested. Our attendance was intermittent and spasmodic, so the wasps could not regard us as part of the natural surroundings of their home; but we were always "calm and unflurried," and were probably regarded as something harmless about which they need not worry.

But to return to the Peckhams' observation: "The entrance to the *Vespa* nest was but an inch across; and once when they were going in and out in a hurrying throng, jostling each other in their eagerness, we counted the number that passed, one taking the entrances and one the exits. In ten minutes five hundred and ninety-two left the nest, and two hundred and forty-seven went in, so that we saw eight hundred and thirty-nine or about eighty to the minute."

The wasp is no exponent of the eight-hours movement. As soon as the sun has had time to take "the raw edge" off the air the wasp is out on her everlasting search for provisions or building material; and she works on until long after sunset. To enable them to arrive at an estimate of a wasp's daily labours, Mr. and Mrs. Peckham kept watch on the entrance of a ground nest from half-past four in the morning until noon, counting the wasps that went out and those that came home. In that time 4,534 left the nest and 3,362 returned. "With all this activity there seemed to be no pleasure excursions, for each one carried food when returning, and took out a pellet of earth when leaving." They calculated that each wasp was gone about forty-three minutes.

The British species of wasps already enumerated are, as regards six of them, so similar in their natural history that it is unnecessary to treat them in detail. A seventh, being an interloper into the nests of others, by whom its brood is reared, does not fall under the category of artizan, unless we are to regard burglary as a handicraft.

But the eighth species—the terrifying Hornet (*Vespa crabro*), is entitled to a few words of separate treatment. In all essentials its nest is internally like that of the smaller wasps, but it is usually built in the hollow of a decayed tree, often in a corner of a disused outhouse, sometimes in a roof beneath the thatch. It is said to use *rotten* wood as the raw material for its paper-making; but

though we are not in a position to assert otherwise, we think the statement is open to question. The smaller species of *Vespa* select fibrous material, and it is scarcely probable that the larger insect would prefer a more fragile substance for her larger works. It has also been stated that the darker colour of her paper is due to its being made from bark shavings.

She does not leave off work when night comes on, for she may be seen on moonlight nights, seeking her prey. At times she is found by moth-hunters industriously lapping up the sweet mixture known as "sugar" which they have painted in broad streaks on tree-trunks for the allurement of night-flying moths. Often when her tree-hollow is of a sufficiently enclosed character, the Hornet will omit the paper walls of her nest, and thereby save much labour which can be devoted instead to the building of combs and the care of her grubs.

The genus *Polistes*, of which *P. gallica* is a well-known Continental species, builds combs suspended from branches and attached to rocks, but without any paper nest surrounding them. In some books where this comb has been figured it is shown as a horizontal structure, with the cells opening upwards. The natural position for the comb is vertical, and of the cells horizontal with their openings outwards, an arrangement that is also found in the combs of the Honey Bee.

Ischnogaster melleyi, a long-waisted Javanese

wasp, builds its combs in a similar unprotected fashion; as also does the South American *Apoica pallida*, but in this case the convex upper surface (or back) of the comb is covered with a continuous sheet of firm paper which is dense enough to cast off tropical rain. *Synœca cyanea* attaches its combs to the branch of a tree, moulding them to its curves and angles for a distance of two or three feet, and building an outer envelope of paper to protect them.

All these nests, like those of our native species, are built for one season only; but there are wasps' nests built for continuous communities like those of the Social Bees. These are found in South America, and in consequence of their being intended to last for more than one season they are built of much more durable material—though it is produced in the same way as the ordinary fragile paper. "Paper" is not the word for this material. It is thick, tough, solid, with a smooth finished surface, and the term *papier mâché* is much more suitable for it.

A tolerably well-known example of this type is the nest of *Chartergus chartarius*. As it hangs from a branch it is bell-shaped, with the mouth closed save for a small opening in the centre large enough to admit the builders. Some of these nests are a foot and a half high, and contain ten or more tiers of comb, which are concave on the upper or blank side and convex on the cell side. These combs, instead of being suspended

one from another, are attached by their edges to the walls, and access from comb to comb is provided by a central opening. This arrangement, it will be seen, provides a box-like structure, very strong and enduring, even when exposed to tropical storms.

Somewhat similar are the nests of the genus *Polybia*, which are of various shapes according to the species that build them, one of the most remarkable being that of *Polybia scutellaris*, a native of Brazil and Uruguay. It is about a couple of feet deep and three feet in circumference, its envelope of thick card like that of *Chartergus*, but instead of being smooth the surface is beset with stout spikes of the same material, which have been supposed to be a defence against the attacks of mammals that have a sweet tooth—for, strange to say, this wasp stores honey in some of its combs.

We say "strange," but it is strange only in contrast to the habits of most of the wasps we know. Even the insect-feeding wasps are fond of sweets, but they do not store honey because they do not require it for winter consumption. If one considers why bees store honey, it appears quite natural that a community of wasps that continues unbroken for years should do the same. This point of view, however, never occurred to the naturalists of a hundred years ago, when the existence of honey-storing wasps was first brought to their notice. They rejected it as a traveller's tale.

The first intimation of the existence of honey wasps was made by the Spaniard, Don Azara, who had spent thirteen years in the work of a boundary-delimitation commission in Paraguay at the end of the eighteenth century. His published account of his travels was much criticized because of this statement, and whilst some regarded it as a pure concoction of the Munchausen class, others thought the insects he considered wasps were really bees. When about forty years later specimens of the nests reached this country, and were examined, Dr. Adam White, of the British Museum, found dry honey in the combs, and the reputation of De Azara was rehabilitated. Since then other species of *Polybia* have been discovered to have the same habit.

Wasps, however, are not the only paper-makers among these Insect Artizans. A few ants practise the art, among them species of *Polyrachis* in the tropics of the Old World; also *Dolichoderus*. Some of the former construct little nests on the surface of leaves. These are paper-like in structure, consisting of a single cavity lined with silk, and serving for the accommodation of a single female and eight or ten workers. For the purpose of making these structures inconspicuous, some species cover their nests with fragments of vegetable matter, or hide them between two leaves.

Our Carpenter Ant (*Lasius fuliginosus*) is a cardboard-maker on occasion. If in its excavations a worker has been unmindful of the needs of the

nursery or other department, and has made halls or corridors too wide or lofty for comfort, others will set to work erecting partitions by elaborating from wood debris and saliva a rough cardboard that serves the purpose and harmonizes with its surroundings.

VIII

TAILORS

VIII

TAILORS

We have done with the communal builders, and with those that construct dwellings for their progeny whether by mining, masonry, carpentry, or otherwise. Our present business is with the individual who, not satisfied with the provision made by nature, makes an additional covering that he may avoid being seen by creatures that would attack and eat him. With many species there is inherited knowledge of the fact that the way through life is beset by dangers, that enemies are looking for their victims on all sides, and that the sooner the intended victim can make himself to look like something unpalatable the better for his chance of fulfilling the destiny of his kind. So, as soon as they have quitted the egg-shell, we find certain insects making arrangements for a disguise; though in some cases not so much for protection against more powerful foes, as to enable them to fall upon a victim without creating suspicion.

The venerable Archdeacon Paley, whose book on Natural Theology was once popular reading, averred that man is "the only animal which can

clothe itself." How little ground he had for that assertion will be seen in what follows.

These insect tailors differ from human tailors in the fact that they are only concerned in clothing themselves. They may be considered in two distinct groups: (*a*) those that obtain their materials from their food-plants or bits of the immediate surroundings of their feeding-ground, and (*b*) those that rely upon their own secretions or excretions.

As in the case of the Spinners and Weavers, it is among the caterpillars of the moths that we find the most numerous examples of the first group, their succulence making them desirable prey to all kinds of insectivorous creatures, and their feeding-grounds, being the foliage of plants, expose them to the attack of their enemies. In consequence many caterpillars adopt the elementary precaution of lightly spinning together two leaves of their food-plant, so as to enable them to feed in secret. An advance upon this plan has been adopted by species having a better knowledge of mechanics. These roll up the leaf from one edge into a cylinder of several thicknesses whose shape is retained by a few silken threads, and in this they feed upon the inner coils.

But this is only primitive tailoring, like that of the human savage who clothes himself by wrapping his body in the untrimmed and unsewn skin of the beast he has slain in the chase. What we understand by insect tailoring involves the use of

PLATE 24 STRANGE PORTABLE HOUSES. Page 182

Caterpillars of the Psyche-moths construct cases for their protection whilst feeding. The upper examples, which have passed for snail shells, are constructed wholly of silk ; the lower is of silk covered with vegetable débris. The moth is a male, the female being wingless and never leaving the case in which she fed as a caterpillar.

PLATE 25 TWO TAILORS. Page 192

By an ingenious method, described in the text, the caterpillar of a tiny moth constructs a suit of clothes from the leaves on which it feeds. Two of these are attached to the plant in the first photo, another is shown separately. The second photo shows in the lighter patches where the grub of the maple leaf-cutter has been at work. The dark disc is the garment made by it for winter protection. One side of it is leaf, the other side silk. A faint indication half-way up the leaf shows where it was formed.

Photos by Author.

the shears, the making of neat seams, and the finishing off and fitting. These forms of disguise are chiefly found among the moths and beetles, the former adapting foreign materials to their use, and the latter relying chiefly upon their own substance.

Among the best known of these lepidopterous tailors—from the fact that figures of their "cases" have frequently appeared in natural-history books—are the caterpillars of the genus *Psyche*. These, as soon as they quit the egg, spin a silken jacket, attaching to the exterior bits of the food-plant which they have bitten off. These pieces are attached by one end only so that they overlap. The one suit of clothes serves them until they become moths—in the case of the females all their lives. As the caterpillar increases in size it adds to the length and breadth of the case, which serves also as a cocoon for the chrysalis. The males develop wings and are active fliers, but the female is a helpless, wingless and legless, worm-like creature, and has to remain in her case till death. Some of the allied species make more remarkable cases, so that they resemble little snails of the genus *Clausilia*; others are like the shells of *Helix*, for which they have been sent to this country by collectors.

Somewhat similar are the clothes made by various species of small moths that are collectively known as Clothes Moths. There are at least three distinct species, with different habits, that are

known by this common name in this country. They are insects that have scarcely to be sought, for, quitting the fields, they have taken to a life in our homes, laying waste our furniture and clothing. Some of them get beneath the covers of chairs, sofas, etc., and work their mischief out of sight.

The Clothes Moth properly so-called (*Tinea pellionella*) works to some extent out of sight, but that is because it is a tailor, and weaves itself a coat partly of its own silk and partly of the human garment it has set out to destroy. Every housewife knows this cleverly made cylinder of cloth or silk or fur, which needs sharp eyes for its detection so closely does it resemble the garment on which it is found, but we fear that she is too eager to destroy it to find out much about its structure, and scarcely in the right frame of mind to admire it. If she were sufficiently calm to examine it before bringing the back of the brush down upon it, she would find that the occupant is a tiny whitish caterpillar with a brown head.

Like *Psyche*, this caterpillar, as soon as it has left the egg, spins a silk case, weaving into the exterior snippets of hair or silk or wool (it will not touch cotton or linen), and adding to this as its own growth demands more room. It might be supposed that with a well-stocked wardrobe at its disposal it would make a new suit of clothes as occasion requires; but it is too economical to do so. The question of increased length is a simple

matter : it has only to add new material to the ends. But when the case gets too tight there arises what might appear to be a problem. There are no seams to be unpicked and "let out," but a gusset (we believe that is the correct term) can be inserted which has the desired effect.

When things have arrived at that pass when a pressure is felt and the further indulgence in food threatens to become inconvenient, the case is deliberately cut along one side from the end to the middle, and in the gap new material is woven. Then a cut is made from the other end also to the middle and new material inserted there. The process is repeated along the other side of the case to preserve symmetry. Result—a sufficiently roomy jacket is secured without depriving the owner of its protection whilst the alteration is being effected.

The method of using this case without the movements of the caterpillar being impeded is as follows : the insect clings to the silk lining by the claspers on the hind body only. The six legs just behind the head are always kept outside the mouth of the tube, and with these it walks, dragging its case with its body. That is why these cases fail to fall off with only a slight brushing of the garment attacked. Sometimes, however, one gets brushed off without being seen. The mistress of the wardrobe has taken away the blue garment to wear and has knocked off a Clothes Moth caterpillar in its blue case. It climbs up the article nearest to hand, which happens to be red. The result is that

when it has occasion to enlarge its case a red gusset is let into the blue material, and the contrast of colour renders the supposed protective covering rather conspicuous. Experimentally in close confinement the little tailor has been made to weave a coat of many colours by placing it successively on cloth of different hues.

Before becoming a chrysalis, the caterpillar either leaves the garment upon which it has fed and retires into an obscure corner, or it remains where it is, and secures itself from falling or being brushed off by spinning mooring threads between each end of the case and the garment. The little moth that finally results from this caterpillar has the fore wings yellowish brown with a dark-brown spot near the middle of each.

Another species of these case-makers allied to the Clothes Moth is *Tinea vastella*, that feeds on the horns of living antelopes in Africa and India. It makes cylindrical cases of a felt-like material composed of the comminuted fibres of horn; and as those of full size are three inches long with a breadth of about one-fifth of an inch, and stand out at right angles from the horn, they present a remarkable appearance, which might lead a hunter to suppose he had come across a new species of antelope.

Many minute moths with a similar taste for tailoring feed upon vegetable matter—which the Clothes Moth despises. Good examples of these may be found in the large genus *Coleophora*, of

which we have no fewer than seventy-five native species, and of which some are extremely common, though remaining scarcely known except to the specialist. The garments they fabricate are all so small that we never notice them until the plant they are on is subjected to a very close inspection. One of the commonest forms may be found upon the leaves of birch, elm, alder, etc. This is *Coleophora fuscidinella*, of whose operations Mr. Alfred Sich, who has made a special study of this group of moths, has given a full and interesting account, from the laying of the egg to the emergence of the moth. He says:

"The moth lays her eggs on the under side of the leaves, and the minute caterpillar after hatching bores a hole in the leaf and makes, in the course of a few days, a pear-shaped mine. Here it undergoes its first moult or change of skin, and when that is accomplished it sets to work to make its first case. It moves round the mine and clears out any portion of the parenchyma which would come in the way of its case. It now cuts a slit in both the upper and under cuticles of the leaf, from the top to the bottom, on one side of the portion it intends cutting out, and fastens these two together at their edges with silk. It then treats the opposite side in the same manner, taking care, however, to leave a portion at the apex, and at the base of the case, still attached to the leaf.

"When the sides are completed the larva crawls up to the top and severs the two cuticles at the

apex of the case from the leaf, but does not fasten them together, as it requires an aperture at this end of the case as well as at the basal end. After this the larva crawls down to the base of the case and severs it completely from the leaf by biting through first one cuticle and then the other, so that before the second cuticle is cut through the larva is able to grasp the leaf firmly with its legs and prevent itself and the case from tumbling down.

"The case now being complete, the larva walks off with it in search of fresh food. Having found a suitable leaf, it fastens the mouth of its case by silk to the lower cuticle and then bites out a round hole in the cuticle through which it enters the leaf to feed on the parenchyma. When it has eaten out as much as it can conveniently do without quite leaving its case, it usually cuts this away and carries it off to another suitable place, where it forms a fresh mine.

"In this manner it continues to feed and also to grow longer and stouter, so that its case gets too small and has to be made larger. At this period of its existence this species lengthens its case by adding rings of leaf cuticle to the anterior end of its case. When about to remove to another leaf it does not cut away the actual case, but it cuts out a ring of cuticle round the mouth of the case, thus freeing the case with the ring attached, so that this ring becomes part of the case. . . . The case, however, as the larva grows stouter, must be made more spacious, so the larva unpicks the

lower seams of the case which it previously, with such pains, sewed together, and lets in a width of silk. When the case again needs widening, this width of silk is cut down the centre and another width added.

"By these additions this species thus continues the size of its case till the autumn sets in. The case is now about one-tenth of an inch long. The larva then prepares for hibernation. It crawls off the leaf and fastens its case very firmly to a twig of its food-plant, as if it knew that, did it remain on the leaves, it would fall to the ground and might be blown far away. The site usually chosen is the space found in the angle between the bark of the twig and the next year's leaf-bud. Wedged closely down in this situation, the minute larva, secure in its self-made dwelling, braves the autumnal gales and the winter's cold without any further protection."

When in spring the new leaves expand the larva loosens its hold, and travels to a chosen leaf where it begins to feed again, and in due course enlarges its case. In the spring the human tailor has a rush of work because the spring sunshine makes the clothes of his customers appear shabby and they call for a new suit. Whether similar emotions stir *fuscidinella* to action has not at present been determined by investigators; but Mr. Sich tells us that—

"In May, when the larva has grown considerably, something impels it to abandon its old case and

make an entirely new dwelling. It fastens its old case to the basal portion of a leaf close to the edge, and then mines out a space along the margin of the leaf, nearly twice the length and double the width of its body. To do this it comes, of course, quite outside its old case, and when the space is quite completed it severs the large new case from the leaf in the same manner as it did when making its first case, and then crawls off to feed. This new case is rather flimsy and translucent, but in a day or two the larva causes it to become very tough and quite opaque.

"The inside of all the Coleophorid cases I have examined is lined with silk. The threads, running in all directions, are plainly visible under the microscope. It is this silk lining which, by providing a firm foothold for the larva, enables it almost instantaneously to withdraw its body into the case when alarmed. I think it highly probable that the interior of the case is also strengthened by some other material secreted by the larva, as many cases appear to be formed of a substance resembling parchment which could hardly be formed by leaf-cuticle and silk threads without the aid of some stiffening material. Dr. Wood suggests that this material may be the product of the salivary glands."

The new case, as Sich goes on to tell us, is straight, cylindrical, and has about thirty times the capacity of that in which it passed the winter. It feeds for about a fortnight longer on the lower side of the leaf, then removes to the upper side, fastens its

case securely and changes to the chrysalis condition. One cannot see what goes on behind these opaque walls, but evidently it doubles on itself, in spite of the straitness of its cell, for whereas the caterpillar was head downwards, the chrysalis is head upwards. A few weeks later it emerges as a moth from the summit of its little tower.

In a general way this may be said to be a statement of the proceedings of all the numerous species of *Coleophora*; and yet when one comes to study them as Sich has done, there are found to be innumerable interesting differences of detail peculiar to each species. Thus *Coleophora discordella*, which feeds upon the bird's-foot trefoil (*Lotus corniculatus*), enlarges its case by adding a mined-out leaflet of the plant, and as at each successive enlargement it uses a leaflet larger than the last, the case "forms an almost perfect miniature cornucopia." In its last stages of construction the caterpillar does not trouble to nip off the two side leaflets of the leaf, so these are added although not attached to the case.

Some of them live upon plants whose leaves or leaflets are too small to have pieces cut out of them: the caterpillar has to take all or none, and, of course, it takes all. Thus *C. saturatella* feeds on broom and employs a whole leaflet when enlarging its case. "It spins its case to the leaflet, just below the apex, and mines out sufficient to clear the top of the leaflet. It then splits the leaflet right down the centre, wedges its case in between

the split portions and fixes it there with silk. Afterwards it mines out the rest of the leaflet and cuts it off at the base, so that the central and basal parts of the leaf form the tube where the larva lives, and the apex on one side and the split-off part on the other furnish the ornaments of the case."

Another species, *C. juncicolella*, that feeds on heather, so constructs its case of the leaves that the finished article cannot be distinguished from the plant upon which it is placed.

Coleophora siccifolia was known to a past generation of entomologists as the Clumsy Tailor, "on account of the apparent waste of materials employed in making its case; and when feeding in its last case it certainly appears to be carrying far too much sail." But there is method in its madness. "It feeds up in the autumn, and attaches its case to a hawthorn twig to pass the winter and early spring. When in this situation it looks so exactly like a withered leaf that I have wondered whether even the tits and other insectivorous birds are aware that the faded leaf shelters a living caterpillar. . . . It makes altogether three cases, and in making the third, and naturally the largest one, it usually mines out and cuts off the whole of the apical third of a hawthorn leaf. It forms a silken tube in the mine, and inrolls one of the margins to protect the tube in which it lives. The rest of the leaf is spread out like a wing on the other side, till time gives it the curl which so many dead leaves assume."

An allied species, *Pseudodoxia limulus*, makes a case of minute fragments of moss, lichen, and grains of sand. The caterpillar feeds upon the mosses and lichens that grow on rocks and trees in the island of Ceylon, and the materials of which the case is composed give it a doubly protective character since they cause it to assimilate with the surroundings. The lower end of the case spreads out into a shield-like hood which quite hides that part of the caterpillar that comes outside for the purpose of feeding. The hood serves also to close the mouth of the case whilst the insect is in the chrysalis stage, for before undergoing the change the full-grown caterpillar moors its case to the rock or tree, and folding down the edges of the hood as though it were the flap of an envelope, secures it in position with silk threads.

Bates mentions a caterpillar (*Saccophora*) he met with on the Amazons which has this tailoring habit, but on a much larger scale than those we have been considering. The caterpillar feeds upon various species of Melastomaceæ, and constructs cases by selecting suitable-sized leaves of its food-plant and converting them into tubes by rolling the edges one in the other and securing them with silk. They make the interior comfortable by lining it with a thick web of silk. The case inhabited by a full-grown caterpillar is two inches long, and as the weight is too great to be constantly supported by the insect, when it moves to a new leaf with a view to eating it, the case is attached by a few threads

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to the leaf or to a twig that will enable it to reach the leaf.

If in summer time we visit any considerable pond where there are plenty of water-weeds, we are sure to be attracted by the sight of numerous pretty moths flying about over the water and settling on the aquatic vegetation. These represent several species of Pyrales, and are popularly known as China-marks from the character of their wing ornamentation. The reason for their presence in this rather unlikely habitat for day-flying moths is that their caterpillars are aquatic, which in itself is an unusual thing for the caterpillar of a moth.

The caterpillar of the Brown China-mark (*Hydrocampa nympheata*) feeds upon the leaves of the Broad-leaved Pond-weed (*Potamogeton natans*), whose brownish, oily-looking ovals float with the lower surface in close contact with the water and the upper surface exposed to the air and always dry. Now the caterpillar might feed on the upper surface of the leaves and, so long as it did not eat through the lower cuticle, run little risk of being drowned. But this the species has probably found out in the far past would expose it to the attacks of many enemies. So it has chosen to spend its existence as a caterpillar on the under side of the leaf, though this necessitates always being submerged.

But our caterpillar is one of the tailors, though not one of the common run. Long before man ever thought of descending into deep water dressed in a watertight costume that contained air, our

little *Hydrocampa* had elaborated an outfit that enables it to remain under water for months. It is an air-breather, and it is necessary therefore that its dress should contain a considerable volume of that commodity. This it does by cutting out a piece of leaf of the desired shape and size from the under side of the leaf. This is attached to another part of the leaf by silk threads in such a manner that the two under surfaces are opposed. The reason for this detail is that the leaf is slightly concave beneath, and when the two concavities come together they form a hollow pouch. The second leaf is then cut to correspond with the piece attached to it, so that there is now a lentil-shaped case quite detached from the leaf and available for removal from leaf to leaf.

In ponds where the yellow water-lily grows as well as *Potamogeton*, the caterpillar, as the summer advances, transfers its case to the former plant, the more fleshy leaf probably supplying a more suitable pabulum for its increased size. When the caterpillar is full-grown it is about an inch in length.

The caterpillar does not feed upon the material of its case, as is done by some other tailors, so the problem to be solved is how to construct the case that it will keep out water and yet permit the caterpillar to put out the fore part of its body for the purposes of feeding and locomotion. At one end of the case the edges are left unsewn for a small space, just sufficient to allow the caterpillar to protrude, but the opening is so contrived that

when the head of the insect is withdrawn the lips of the opening press together as though closed by a spring.

A remarkable feature of the story is the fact that when the caterpillar emerges from the egg it is a purely aquatic insect, breathing through its skin the oxygen that is dissolved in the water, for its system of air tubes is not developed and their external openings are closed. At this period, too, it is a miner in the leaves of *Potamogeton*, and its mines are full of water. Its skin is smooth and remains wetted. Its mining life only lasts a few days; then it becomes a tailor, fashioning a suit of clothes that is only a protection from enemies.

It was born in July or August, and like other larvæ it casts its skin several times to allow increase of size, but no striking change takes place in its structure or habits until the following May. Then it constructs its waterproof suit of clothes. Then its new skin is studded all over with conical points, large and small, which serve to keep air entangled between them, so that if you take it out of its case and drop it in the water it will not become wetted. The spiracles along its sides open to admit atmospheric air to its fully developed system of air-tubes (*tracheæ*), and its new case remains always filled with air. In June or July—after a short period of rest as a chrysalis—it emerges as a beautiful moth, which flies among the reeds.

Very similar is the story of the Small China-mark (*Cataclysta lemnata*) which begins life as an aquatic

caterpillar, and later breathes air; but it makes its suit of clothes of the minute fronds of duck-weed (*Lemna*) that float on the surface of most ponds. These are sewn together, as it were, by silk threads to a silken lining.

Much more generally known to those who have paid no special attention to entomology are the quaint little creatures known as Caddis Worms, though they are not worms at all, but the caterpillars of hairy-winged, dull-looking Caddis Flies (Trichoptera). Every one who has peered into the waters of a running stream, or of a clear stagnant pool, has seen these remarkable constructions moving over the bottom; and has felt a momentary interest, at least, in the clever tailors who could fashion such costumes for their protection.

The pond is a dangerous place of residence for any tender and juicy creature that is not gifted with power of swift movement, or raptorial limbs or jaws; and the Caddis Worm has not been so provided. There is a long cylindrical body with a skin of the tenderest character, except the head and three adjoining rings to which the legs are attached; these have horny coverings. So the Caddis weaves himself a silken tube to which he attaches, as he proceeds, bits of foreign substances which convert the tube into a stronghold from whose door the armour-clad head and legs can protrude and haul the structure along.

Caddis Worms are of many species, and according to the traditions of his kind each Caddis selects

the materials he considers most suitable for the circumstances of his life. One species (*Limnophilus pellucidus*) is content with bits of leaves which enable him to pass unnoticed among the waterweeds from which they were bitten. *Limnophilus rhombicus* takes short pieces of grass-stem or bits of horsetail and arranges them transversely to the length of the case, so that the finished effect reminds one of a hedgehog. *L. flavicornis* is not so exclusive in its choice of material; it will make its case of bits of thin twig not very orderly in their arrangement, or it will capture small water-snails, chiefly species of *Planorbis*, but often the little freshwater bivalves (*Sphærium*), in either case with the shell still tenanted by its builder. Such a dress of living molluscs is apparently cumbrous by reason of its weight, so we often find that the tailor has redressed the balance by fixing along each side of his tube a bit of stick perhaps twice its length. This gives the required buoyancy, though not sufficient to float the structure. *Anabolia nervosa*, which makes its case of small fragments of stone, adopts the same method for lightening it. *Sericostoma* and *Setodes* make their cases of sand, very neatly spread over the silk lining, slightly tapering and curved. *Setodes* is in form exactly like the marine shell known as the tusk shell (*Dentalium*).

These cases, carefully examined, will be found to be broader at one end than at the other—" and thereby hangs a tale." The Caddis Worm, as the advance of life causes it to increase both in girth

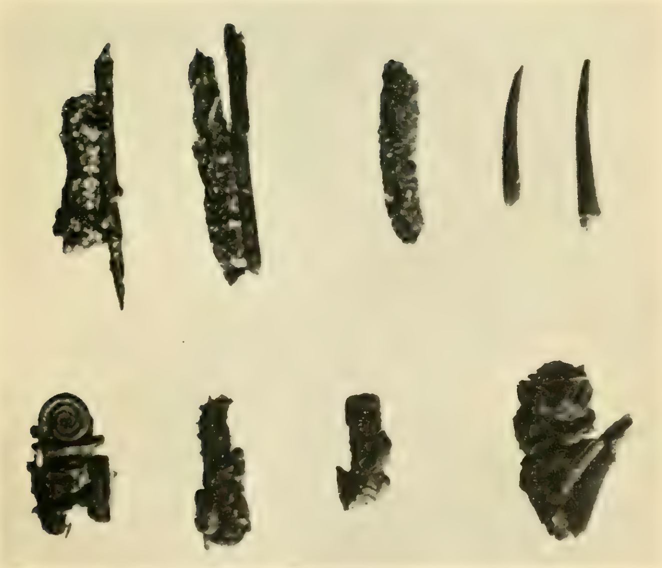

PLATE 26 CADDIS-FLY AND CADDIS-CASES. Page 198

An example of the four-winged flies whose aquatic grubs construct portable houses, varying in shape and material according to the species of builder. The upper ones are of grains of sand cemented, two of them strengthened by small sticks. The lower are of bits of wood, leaf and snail-shells.

Photos by Author.

PLATE 27 THE AGRICULTURAL ANT'S CLEARING. Page 214

This ant clears a space of grass and weeds around the entrance to its nest, and is said to plant on it a particular kind of grass whose seeds it gathers and stores. Roads radiate from the entrance in various directions.

and length, does not provide for the increment in the way adopted by the caterpillar of the Clothes Moth. The Caddis Worm's method set down on paper may look suspiciously like that of the legendary Irishman who is said to have lengthened a too short blanket by cutting a piece off the top and sewing it on the bottom. As the Caddis case gets too strait, he cuts a piece off the rear, which is the inconvenient portion, and makes additions to the front end. By always maintaining the slight tapering form in this way, there is never any necessity to split the case down the sides and insert gussets.

Before the change to the chrysalis stage comes the Caddis Worm prepares for it by stopping up the ends of its case against unfriendly visitors. Care is taken, however, to allow a sufficient gap for water to flow through, for even in the pupa state it requires to breathe. The stopping is variously effected according to species: some using vegetable debris to form a plug, others spinning a grating of silk threads.

Micropterna, which lives in swift streams, takes precautions against its case being swept down-stream, and perhaps buried, owing to the absence of guiding limbs from its doorway. Its method is to get bigger stones than its case consists of, and to attach these to the front or wider end. It then closes up that end with a silk grating, doubles on itself in the case, and thrusts its head out at the smaller end. It digs a hole in the bed of the

stream wide enough and deep enough to admit its case, which it then up-ends and allows to sink into the pit until stopped by the larger stones recently added to the other end. It now resumes its former position in the case and changes into the chrysalis. Its case is now a vertical tower, fixed by the weight of its upper end. The pupæ escape from their cases before undergoing the final change into Caddis Flies; and whilst some species emerge from the chrysalis at the surface of the water, others first make their way to land.

Among the allies of the Caddis which turn their clothes into fixed residences by attaching them to stones, etc., are several species of the Hydropsychides. One of these, *Rhyacophylax*, which Möller found in the rapids of Brazilian rivulets, in addition to its suit of clothes, or house, proper, builds a funnel-shaped verandah to it. The verandah is covered with a delicate network of silk. Now the house is always built with its door looking up stream, so that as the current flows through the network of the verandah anything suitable for food is strained out and falls handy to the mouth of *Rhyacophylax*. Somewhat similar is the device of a North American species of *Hydropsyche*, which attaches the widest circumference of its net to bits of twig and the stems of water weeds. These two are entitled to be classed as Trappers as well as Tailors.

We have already described the way in which the caterpillars of the Coleophorid moths, beginning life as leaf-miners, make for themselves portable

houses. Another leaf-miner, but of the order Hymenoptera, and the Sawfly family, shows remarkable skill as a cutter-out and liner of a winter garment. This insect is the Maple Leaf-cutter (*Phyllotoma aceris*), and the grub subsists by entering the substance of maple and sycamore leaves and eating out the cellular matter between the upper and the lower cuticles. It is a very soft and delicate creature, and apparently it fears that when the leaves dry up and fall in autumn, it, too, may dry up. So it sets to work to circumvent fate; and does it.

The sycamore-leaf has five pointed lobes, and the grub always begins its operations at one of these points, cutting away and eating on either side and in front of him from that point, leaving an area behind him from which the green material has been completely cleared. At length he appears to feel that he has eaten all that is necessary to enable him to work out the remainder of his destiny fasting.

He now sets to work to cut out his winter clothes. Without the aid of compasses he strikes out a true circle in the upper cuticle of the leaf. With his jaws he makes a series of cuts, each one forming a segment of the circle, but separated from the next cut by a minute interval of unbroken skin. He finishes within the breadth of a pin at the point where he started, and the circle has taken nearly an hour to cut. The circle is now complete, but it remains attached to the rest of the leaf much as

a postage-stamp is attached to its fellows in a sheet of stamps. One can be removed from the centre of the sheet by a little pressure. The perforations in the leaf are short gashes instead of the dots of the stamp-sheet. Here, again, it will be seen, is an anticipation by nature of a human invention.

Having all but separated his disc, our grub proceeds to weave an exceedingly fine tissue of silk from the edges of the disc, making a complete floor beneath himself. This appears to us to be an exceedingly clever piece of work, much more so than the weaving of the oval cocoon cleverly constructed by the caterpillars of many moths. There the spinning is in all directions, and the caterpillar has room to move as he pleases to effect it. In the beginning of that work, as we have shown in our first chapter, the caterpillar attaches threads to all available points to form an outer scaffold, inside which he can fashion his egg-shaped cocoon with comparative ease. In the case of our Maple Leaf-cutter not one of his threads may extend beyond the cut edges of his disc, or his purpose will be defeated. The fabric to be woven is a flat tissue, and this part of the performance may be likened to a weaver lying in bed and weaving a complete bottom-sheet under his body.

The grub is equal to his task; for the next we know is that the disc has separated from the rest of the cuticle, and is now the upper side of a circular flat bag, the lower side being of closely woven silk, and the grub lies snug between. How the separa-

tion from the leaf is effected is by no means clear. It has been suggested that it is due to the pull of the silk threads beneath; but this can scarcely be so, as the silk floor sags slightly in the middle, which indicates that it is not taut, whilst the vegetable roof is flat. Our own theory is that the almost complete severance of the disc from the rest of the leaf cuts off so much of the supply of moisture that the disc contracts and so effects complete severance.

You may be looking at one of these discs, still in position on the leaf, when suddenly it separates and drops to the ground. The disc, if it has alighted on an unsatisfactory spot, begins to move about with shuffling jerks, apparently due to the grub taking hold with its hind body and suddenly jerking the bulk of its body to one side. Judging from the fact that the way to induce these movements is to expose the disc to strong sunlight (or electric light) they appear to be a provision against the grub getting dried up. It seeks a shady, moist position, where it can lie safely all through the autumn and winter. Not until spring does it change into a chrysalis in its cell, and a little later, when the maple and the sycamore are in leaf, a four-winged Sawfly emerges, and sets about providing for the continuance of the race.

So far we have considered tailors that rely entirely or partly upon materials they have adapted to their use. We have now to glance at a group which construct clothing from the waste products

of their bodies. The insects that work in this material are chiefly the grubs of beetles; but there is at least one remarkable example from the moths. This is a South American species, known as the Hammock Moth (*Perophora sanguinolenta*), from the extraordinary performance of the caterpillar. Several allied species make cases for themselves by sewing up the edges of leaves, and carry these about from place to place on their food-plants, temporarily fixing them by silken threads, and, when they have exhausted the food within reach, cutting the threads and moving the case to a more leafy part.

The caterpillar of the Hammock Moth, however, utilizes its own excrement, which is of a form specially suited for this use, and builds up a spindle-shaped case which is enlarged as the caterpillar grows. It is slung up hammock-fashion by silk threads at each end; and the caterpillar protrudes sufficiently to reach neighbouring leaves, but withdraws entirely when it suspects danger from exposure.

In and about pine-woods where there are the huge nests of the Wood Ant (*Formica rufa*), we may frequently find upon the birch-trees a beetle that is often mistaken for a large kind of lady-bird, owing to the fact that it has red wing-cases and each of these bears two unequal black spots. This is *Clythra quadrimaculata*, the second name having reference to these four black spots. It is really of different shape from the Lady-birds, which are rounder in outline and more convex. The reason

for its presence in the ant-infested woods is that it spends the larval and pupal parts of its existence actually in the nests of the Wood Ants.

Ants' nests harbour a number of other insects, some of which are messmates whose presence is cherished by the ants, some enemies, and some whose class has not yet been determined. The presence of *Clythra* larva in the nest has long been a well-known fact; but why it was there and what it did for a living were problems. It was known that the larva protected itself by constructing a leathery case, and this seemed to imply that its relations with the ants were not of the friendliest character; but beyond that, little was known. Recently Donisthorpe in the course of his investigations into the economy of the ants and their lodgers, has filled in some of the outlines with facts. He says of *Clythra*:

"The beetle itself feeds on the young leaves and shoots of birch-trees, etc. Its female seeks a tree or shrub, above or near a nest of the Wood Ant, and drops her eggs on the ground. She covers the eggs, which she holds with her back feet, with excrementitious matter, which she arranges in layers. This makes them resemble a small bract, or part of a plant; in fact, they look exactly like the end of a birch catkin. The ants pick this up and carry it into the nest, as they do with bits of vegetable refuse.

"When the young grub hatches, it builds a small black case on the covering of the egg. This

case has V-shaped ridges on one side, and is constructed of earth mixed with excrementitious matter. As the grub grows it enlarges its case, by scraping off portions of the inside with its jaws and plastering more on the outside. It feeds on the vegetable refuse of the nest, and also on the pellets of the ants. When full-grown, the grub fastens the mouth of the case to a bit of wood, or other object in the nest, and, turning round inside the case, changes to a chrysalis. When hatched, the perfect beetle cuts a rim round the end of the case with its jaws, forming a cap which it forces off. It then crawls out of the nest and flies away."

The brilliant little beetles of the genus *Cryptocephalus* that are frequent on flowers in sunny places have a very similar habit of protection during the grub stage, though they do not live in ants' nests. Much the same may be said of *Lamprosoma*. The Lily Beetle (*Crioceris merdigera*), whose larva is destructive to the leaves of lilies, disguises itself in the grub stage by covering its back with excrement, which dries into a hard crust. The larvæ of the Tortoise Beetles (*Cassida*) have a similar habit, though a less crude one. Nature has fitted them with a fork-like extension of the hind body which is carried turned up over their backs. Upon this the excrement is spread and forms a sort of umbrella which effectually disguises the insect. An allied species, *Dolichotoma palmarum*, has a more complicated instrument for the same purpose.

Dr. Sharp describes a small beetle of tropical

America, *Porphyraspis tristis*, which is even more remarkable. He says it "is apparently a common insect at Bahia, where it lives on a cocoa-palm. The larva is short and broad, and completely covers itself with a very dense coat of fibres, each many times the length of the body, and elaborately curved so as to form a round nest under which the larva lives. On examination it is found that these long threads are all attached to the anal extremity of the insect, and there seems no alternative to believing that each thread is formed by small pieces of fibre that have passed through the alimentary canal, and are subsequently stuck together, end to end. The process of forming these long fibres, each one from scores of pieces of excrement, and giving them the appropriate curve, is truly remarkable. The fibres nearest to the body of the larva are abruptly curled so as to fit exactly, and make an even surface; but the outside fibres stand out in a somewhat bushy fashion. The construction is much like that of a tiny bird's nest. Señor Lacerda informed the writer that the larva makes a nest as soon as it is hatched."

The Brown Lacewing (*Hemerobius*) in its larval condition is known as the Aphis Lion, from the havoc it creates in a cluster of the Green Fly, seizing them and sucking them dry. From each segment of its body on either side the larva has fleshy projections from which extend several long hairs. Upon these, with the aid of a few threads, it supports the empty skins of the aphides it has

sucked dry, much as the North American Indian of the Fenimore Cooper days used to decorate himself with the scalps of his enemies.

You see a minute heap of rubbish among a host of Green Fly, and if you watch it closely will see a pair of caliper-shaped jaws thrust out and closed upon one of the plant-suckers. It is sucked in turn, and the empty skin is thrown over the hidden head and added to the jacket of trophies with which the Aphis Lion is at once clothed and disguised. Feeding upon such juicy food, he is himself succulent, and would probably tempt a bird to eat him, but no bird is likely to expect to find succulence under that heap of dry skins. Or one might regard this strange jacket as an appeal to the undiscriminating gardener who is "death on all insects"—See what good I have done you! behold the scalps of your enemies!

The Fly Bug (*Reduvius personatus*), which preys upon its detestable relative, the Bed Bug, disguises itself in a somewhat similar way by covering its folded wings, legs, and antennæ with rubbish, chiefly the downy dust which results from the wearing out of cottony and woolly fabrics and is known to housewives as flue. Like *Hemerobius*, it would probably utilize the empty skins of its victims, but it has no hairs long enough to hold them in place; and, therefore, we fear we are scarcely justified in mentioning it under the head of Tailors.

IX

HORTICULTURISTS

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HORTICULTURISTS

PROBABLY there are few passages in the Old Testament that have been so much quoted outside theological circles as Solomon's injunction to the sluggard—to go to the Ant and consider her ways. For hundreds of years it was generally accepted that the further part of it contained the statement that she hoarded up grain to tide the community over the winter. There is, of course, nothing of the kind in the passage; but "profane" writers among the ancients, and of all periods down to the middle of the eighteenth century, were emphatic in speaking of the Ant as a storer of grain. It was not until after 1747, when Gould published his *Account of English Ants*, that the Ant began to be discounted as a moral object-lesson and Solomon as a veracious chronicler.

Gould, drawing his information entirely from his studies of our native species, declared that ants do *not* store up corn. Huber, the great historian of the Ant, probably ignorant of Gould's work, made the same assertion. Kirby and Spence, having studied Gould and Huber, were content to

take their statements as to the non-storing habits of the ants they knew as indicative of the custom of ants all over the world in this respect, and contended that Solomon's words, "prepares her bread in the summer, and gathers her food in the harvest," simply implied that she "with commendable prudence and foresight, makes use of the proper seasons to collect a supply of provision sufficient for her purposes. There is not a word in them implying that she stores up grain or other provision."

So the matter stood until 1873, when John T. Moggridge published a book called *Harvesting Ants and Trap-door Spiders.* Being an invalid without hope of recovery, he had wintered for several years at Mentone, and occupied his leisure in the investigation of the flora and fauna of the surrounding country.

Among the insects that attracted his attention were the ants *Aphenogaster barbara* and *A. structor.* He found that these ants—common to the Mediterranean region, and therefore possibly the kind that the Wise King had in view—*do* store up grain, though not the large seeds of wheat and barley that the farmer has cultivated, but those of wild plants such as fumitory, nettle, veronica, oat, etc. These they gather in autumn, and store them in underground chambers about three inches in diameter. Some of these seeds are collected from the surface of the soil where they have dropped from the plants on the splitting of the ripe seed-

vessels; others are gathered by climbing the plant and wresting off the seed-vessels.

Their store-houses, being underground, appear to be the worst possible places in which to store grain for future use, for they offer the conditions of damp, warmth, and darkness favourable to germination and growth. That they are able to delay this process for some time is evident by the condition in which the seeds have been found by exploring the nest; also by the fact that if the ants are prevented having access to their store-houses, the seeds at once begin to germinate.

When they wish to make use of their hoard they allow a portion to germinate, thus setting up the vital chemistry by which the contained starch is converted into sugar and made available for food. But if growth were allowed to follow upon germination, the sugar would be used up for the nourishment of the seedling plant. So they do what the maltster does with his germinated barley at this stage—he stops further change by killing the young plants. The ants accomplish this by biting off the radicle and the sprouting stem, and then drying their malts in the sun.

But the art of the maltster does not fall properly under the head of horticulture, though we hope it will be seen in what follows that, in the case of the ants, it is a related industry. The discovery of these Harvesting Ants of Europe was, however, anticipated by Lincecum observing similar habits in an American Ant, which was afterwards studied

more closely by McCook. This species is known as the Agricultural Ant (*Pogonomyrmex barbatus*).

Lincecum asserted that the ants sowed the seeds of a particular species of grass, known in consequence as ant-rice (*Aristida stricta*), and that a plot of ground in front of the ant-hill is selected as their harvest-field, and carefully divested of all other grasses and weeds during the season of growth of the ant-rice.

McCook qualifies Lincecum's view of the business by asserting that the ants do not sow the seed of ant-rice, which is a native grass, and therefore sows itself as other species do; but that they clear off all the other growths and allow the *Aristida* a fair field and no competition. They do what all competent agriculturists and horticulturists do: they weed the field in order that the remunerative crop shall lose none of the nourishment that the soil contains. Their instruments are their jaws, and with these they can make a few business-like incisions which put a stop to the further development of the undesirable weeds.

When the seeds of the ant-rice are ripe and fall to the ground they are diligently gathered, and carried into the ant-hill one by one, and stored in special chambers. After wet weather when their corn has got moist and is in danger of germinating before they want it to do so, they bring it out on the first sunny day and dry it thoroughly. Any that have sprouted they leave outside. The Florida Harvester (*Pogonomyrmex crudelis*) is not content

with gleaning: it ascends the stalks and gathers the rice grain by grain.

Above their nest these Agricultural Ants clear a space ten or twelve feet in diameter, and from this clearing several broad roads radiate into the dense herbage to a distance of fifty or sixty feet. Dr. Lincecum mentions one such road that ran straight and smooth for three hundred feet. When one considers the relative proportions of the road and the road-maker, this is an enormous undertaking. Should a weed dare to peep through the surface of one of these roads it is immediately bitten off. There are always streams of vigilant ants coming and going along these thoroughfares, and the traffic serves to smooth and harden them. For the busy creatures are always bringing home supplies of food, and it appears to be the facilitation of this traffic that causes the roads to be made.

These ants appear to take note of the special circumstances of the land they have selected for a settlement. If the ground is ordinarily dry the entrance to the nest is a mere hole in the centre of a gently swelling mound, but if subject to occasional inundation the entrance will be elevated into a steep cone, sometimes as much as from twenty inches to three feet high with the opening at the summit.

It is a moot point whether Solomon—had he known of the existence and the ways of these American agriculturists—would have felt that he could hold them up as patterns to the idle; for

although industry is their prevailing virtue, should they meet with a foraging party returning home laden with provender, they are not so virtuous as to be content with passing the time of day with their kinsfolk from another settlement, but they fall upon them and endeavour to despoil them of the fruits of their labour.

Under the clear disc on the surface are the galleries of the ants connecting with flat-floored chambers in which they live and tend their young, and others that are set apart as granaries. These are placed at a depth of about two feet, so that the grain shall be unaffected by changes of temperature up above; but the galleries have been traced to a depth of fifteen feet below the surface.

In many species of ants there are two grades of workers—workers minor who do most of the work of the community, and workers major who run largely to head and have powerful jaws. These workers major among the agricultural ants appear to be set apart as seed-crushers, using their jaws to crack the hard malted seeds into handy-sized pieces that the workers minor can deal with comfortably, masticating and mixing them with saliva to make them a digestible food for the larvæ.

Dr. Wheeler, the most recent historian of the American ants, supports McCook's view that the ants do not actually sow the seeds of the ant-rice (McCook at least says that Lincecum's statement is not proven); but his statement shows that Lincecum made a not unnatural inference from the facts.

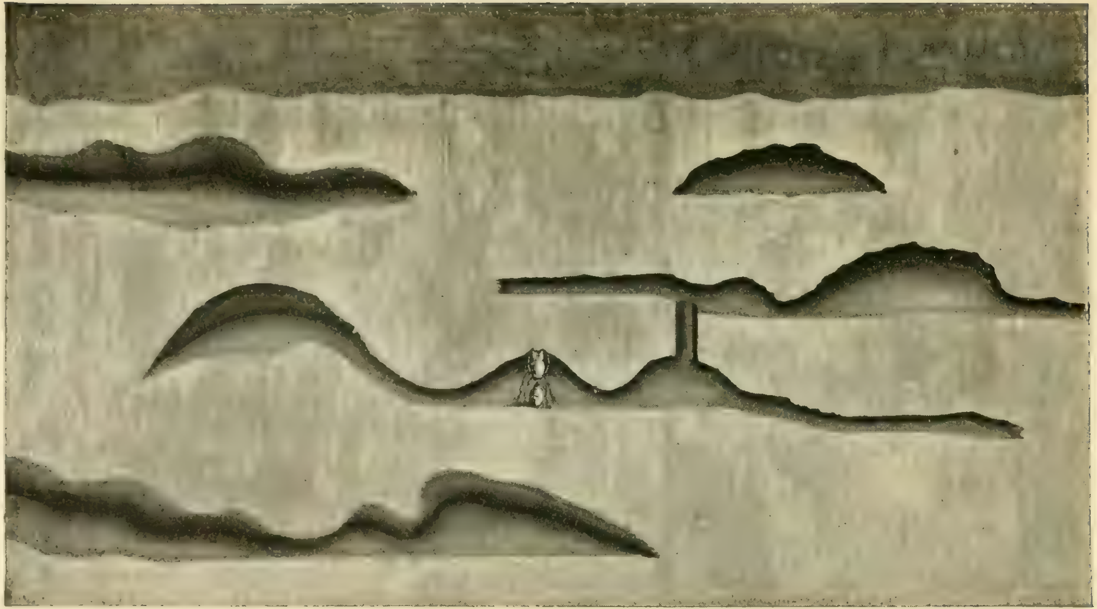

PLATE 28 NEST OF THE AGRICULTURAL ANT. Page 216

A section showing part of the underground nest with the galleries and chambers arranged in stories. An ant is shown working at the enlargement of one of these.

PLATE 29 — MUSHROOM-GROWING ANTS. — Page 218

A party of leaf-cutting Saüba-ants returning with a load of leaves which will be cut up to form new mushroom beds.

Drawn by T. Carreras.

Wheeler says that exploration of the nests in winter reveals many granaries in which the garnered seeds have sprouted.

"Sometimes, in fact, the chambers are literally stuffed with dense wads of seedling grasses and other plants. On sunny days the ants may often be seen removing these seeds when they have sprouted too far to be fit for food, and carrying them to the refuse-heap, which is always at the periphery of the crater or cleared earthen disc. Here the seeds, thus rejected as inedible, often take root, and in the spring form an arc or a complete circle of growing plants around the nest. Since the ant feeds largely, though by no means exclusively, on grass seeds, and since, moreover, the seeds of *Aristida* are a very common and favourite article of food, it is easy to see why this grass should predominate in the circle."

Long before the discovery of these American and European harvesters, however, Colonel Sykes had announced an Indian ant, which he named *Atta* (now *Pheidole*) *providens*, that had somewhat similar habits. At Poona he saw these Ants in January and February storing up the seeds (then ripe) of a species of grass which they took into their nests, and in June and October he saw them bringing up these seeds from their stores and exposing them to the sun in heaps as big as a handful, apparently for the purpose of drying them after being wetted by the rains of the monsoon. He communicated his discovery to the Entomological Society of

London, and the facts are recorded in the first volume of the Proceedings of that body.

But the horticultural ants proper are the terrible Leaf-cutting Ants (*Atta cephalotes*), also variously styled Parasol Ants and (the native name) Saüba Ants. They are natives of Tropical America, and are the pests of those in that part of the world who have established plantations of coffee and orange. The Saüba in some districts makes cultivation impossible for the human horticulturist, in order that she may have plenty of material for her own speciality, which is mushroom-growing. Bates, who gave an account of what he had observed of their operations in Brazil, says they mount the tree in multitudes, the individuals engaged in this work being all workers minor.

"Each one places itself on the surface of a leaf, and cuts with its sharp scissor-like jaws a nearly semicircular incision on the upper side; it then takes the edge between its jaws, and by a sharp jerk detaches the piece. Sometimes they let the leaf drop to the ground, where a little heap accumulates, until carried off by another relay of workers; but, generally, each marches off with the piece it has operated upon, and as all take the same road to their colony, the path they follow becomes in a short time smooth and bare, looking like the impression of a cart-wheel through the herbage."

Bates was not able to discover for what purpose the ants went to all this trouble. He thought he had found the reason, and supposed the leaves were

gathered for thatching the entrances to their underground cities. In this surmise, however, he was wrong, as Belt and Fritz Müller have shown. The leaves are taken down and packed in underground chambers, where they ferment and decay, forming a sort of hot-bed of leaf-mould on which *the ants grow mushrooms!* But why?

The Saüba Ant is a mycophagist! Well, it might be argued, there are plenty of naturally grown fungi in the forests that the Saübas could make use of without going to the trouble to grow them for themselves. True, but the naturally grown mushrooms are seasonal, and their appearance is modified by fluctuations of temperature and humidity. The human mushroom-cultivator has discovered that by preparing suitable beds in dark places where he can control the warmth and dampness, he can have continuous crops; but the Saüba was before him in making this discovery.

Thomas Belt was not content to observe the leaves piled up on top of the nests. He dug out the underground chambers, and found that some of them were rounded and five inches across, three-fourths of the space being filled with a spongy mass of speckled brown material. There were no green leaves to be seen, but he satisfied himself that the spongy mass was the remains of them, acted upon by damp heat after being finely cut up. Through all the mass ran white threads of fungus mycelium. The ant larvæ were brought to these same chambers, and were fed upon bits

of fungus snipped off by the jaws of the attendant workers minor.

To the larger workers is entrusted the task of making these mushroom beds. The green leaves are brought to them, and they cut them into shreds, cleaning each shred by licking it, then rolling it into a little pellet and throwing it upon the heap. It is also stated that when they have completed the formation of a new bed it is inoculated with the fungus by bringing a piece of the old bed with its mycelium threads, just as our mushroom-growers do. When the beds are exhausted and no longer produce the fungus the chamber is abandoned, and the remainder of the mushroom-bed is gradually eaten up by the larvæ of beetles and other insects that are always scavenging in such nests.

Such a method of cultivation by insects should not be dismissed as a mere curiosity of natural history. The process is so complicated that it implies a much higher order of intelligence than is usually allowed to insects by human philosophy. If Lincecum's statement that the Texas ants actually sowed their seeds in cleared ground had been substantiated by later observations, although remarkable it would appear trivial as compared with the conduct of the Saüba; for the Texas ants would have been merely sowing an actual article of food in order to get more of it, much as other species of ant steal larvæ and pupæ from a neighbouring nest in order that they may quickly

raise more workers. But the Saübas laboriously collect green leaves which are not food, and carefully prepare them in order that they may support a crop that may be used as food by them. This is something very different, and is worthy of being pondered.

In addition to their skill as cultivators, the Saübas are notable miners. We omitted them from mention in the chapter devoted to the mining industry because we knew they must be treated here. On this point, therefore, we will be content now with quoting a paragraph from Bates:

"The underground abodes of this wonderful ant are known to be very extensive. The Rev. Hamlet Clark has related that the Saüba of Rio de Janeiro, a species closely related to ours [that is, the Amazon species], has excavated a tunnel under the bed of the river Parahyba, at a place where it is as broad as the Thames at London Bridge. At the Magoary rice mills, near Pará, these ants once pierced the embankment of a large reservoir; the great body of water which it contained escaped before the damage could be repaired.

"In the Botanic Gardens, at Pará, an enterprising French gardener tried all he could think of to extirpate the Saüba. With this object he made fires over some of the main entrances to their colonies, and blew the fumes of sulphur down the galleries by means of bellows. I saw the smoke issue from a great number of outlets, one of which was seventy yards distant from the place where

the bellows were used. This shows how extensively the underground galleries are ramified."

Möller has described similar fungus-growing habits in *Atta discigera* and *A. hystrix* in South America. They make covered ways, nearly thirty yards long and about half an inch broad, leading from their nest to the plants known as *Cupheas*, both in the forest and in the open country. They climb up the stems of the Cuphea; and an ant starts at the edge of a leaf and in five minutes cuts out a piece. When this has been cut almost completely the ant moves off it to the main portion of the leaf, cuts through the remaining part and drags up the now severed disc, grips it with its jaws and lifts it above its head. It then climbs down the stem of the plant, into the covered way, and travels along it at a very uniform pace, and deposits its load in the nest. He found that the average load was twice the weight of the ant, but in some cases it was as much as ten times.

The nest was about six feet in diameter, below the surface of the soil, and covered with a heap of withered leaves and twigs. It was filled with a spongy grey mass excavated into galleries and chambers, so that it resembled a coarse sponge. Through the galleries ants ran, and in the chambers were seen larvæ and pupæ. This sponge-like mass consists of small round particles of the prepared Cuphea-leaves, and constitutes the fungus-garden. When fresh these pellets are dark green, then become blue-black, and finally turn yellowish red.

A clear space is left all around this spongy mass which at no point is allowed to come in contact with the walls or roof. The mass is held together by threads of mycelium, and upon its surface are innumerable minute round bodies of a white colour which Möller termed "Kohl-rabi clumps." These are the "mushrooms" which form the principal food of these ants, and for whose successful cultivation they cut and manipulate the leaves used in preparation of the spongy mushroom-bed. The fungus was found to be *Rozites gongylophora.* If the nest is broken open and the spongy mass scattered, the ants show as much solicitude in gathering up the fragments—especially the newer portions—as in saving their grubs.

In observation nests where these ants were supplied with Cuphea-leaves they were seen to divide the latter into minute fragments, which were crushed in their jaws until not a cell of the leaf structure remained uninjured. It was then rolled into a ball of pulp, and added to the fungus-bed. *Cyphomyrmex*, an allied genus of ant, is also to be included among the fungus growers; likewise *Apterostigma.* The latter lives in decaying wood, and the triturated wood-fibres mixed with the excrement of wood-boring beetles are used for the composition of the mushroom-bed.

An ant of Trinidad (*Sericomyrmex opacus*) has been described by Mr. F. W. Urich as making its nests in clayey soil, with a cylindrical shaft to the outer world standing about an inch above the soil. About

six inches below this opens into a small chamber from which other chambers open out. In the first they store the materials—leaves, petals, etc.—of which when properly treated they make mushroom-beds in the adjoining chambers, which are two or three inches across.

Another class of ant horticulturists are the species of *Camponotus* and *Azteca* of the Amazon region, which construct hanging gardens on trees and shrubs. These are of special interest to the botanist as well as to the entomologist, for the plants they grow are distinct from any that grow elsewhere. Either they have become altered by ant-cultivation as plants have become greatly modified in our gardens, or they have retained ancestral forms whilst their untended relations have become altered by natural selection. Either way, the fact that they do differ is a very interesting one.

The ants carry up particles of earth and form rounded masses of it on the branches. These masses are riddled with passages and chambers, which are strengthened by a lining of paper-like material which the ants manufacture. When the structure is completed the ants sow its surface with the seeds of their special plants, brought presumably from an older garden. As soon as the seeds sprout, the young plants are seen to be carefully tended by the ants, which bring up fresh supplies of soil to add to the circumference, and in this way the garden grows in time to a considerable size. The growing plants surround them with foliage

which shelters the ants' nest from sun and rain, and in due course produce juicy fruits, which are gathered and eaten by the ants.

About fourteen distinct species have been identified as constituting the flora of these gardens. Not one of these has been found growing elsewhere, and it is very rarely that any other plant but these is found in an ants' hanging garden. The plants grown on the *Camponotus* nests up in the branches are all epiphytes—plants adapted for growing on trees away from the ground. *Azteca* makes its gardens nearer to the ground, and the plants it cultivates—distinct from those of *Camponotus*—are not true epiphytes.

The Termites, too, who have borrowed so many of the habits of the real Ants, appear to have taken a lesson from them in the matter of fungus cultivation. Smeathman stated that some species had special chambers in their nests which were devoted to the growing of a fungus which they used as food; but until quite recently no confirmation of this statement was forthcoming.

Now, however, Mr. Haviland has found it to be true in regard to several species. In the case of the South African species, *Termes angustata*, he found that the nursery cells were built of a material which produced a fungus—a kind of mould—upon which were innumerable white bodies (sporangia); and a similar condition was found in some nests explored at Singapore.

In Natal he discovered a new species, *Hodotermes*

havilandi, which he found to be a harvester, and there is every probability that the material harvested is devoted to the cultivation of fungi. During the heat of the day the workers issue from holes in the ground, and with their well-developed jaws cut the grass into lengths of about two inches. These pieces they carry to the mouths of the holes and often leave them there until they have cut sufficient. Where acacia-bushes are growing they also gather the leaflets of that plant.

After the heat of the day has passed they take down the heaps that have accumulated around the holes and store the material in chambers about five feet below the surface. A few chambers near the surface may be used temporarily, but these only hold as much as could be collected in the course of an hour or two. Sometimes, after taking in all the cut leaves, they bring up pellets of clay in their jaws and stop the mouths of the holes with it.

Petch has found fungus chambers in the nests of a Termite in Peradeniya Botanic Gardens, Ceylon, and several Indian species are among the fungus-growers. In the case of the Ceylon species Petch says that the spongy masses which constitute the fungus beds are wholly formed of the excrement of the workers, and that not only are special fungi cultivated on it, but that other fungi, not desired by the Termites, grow, and are weeded out by the workers; when a nest is abandoned these "weeds" grow unchecked.

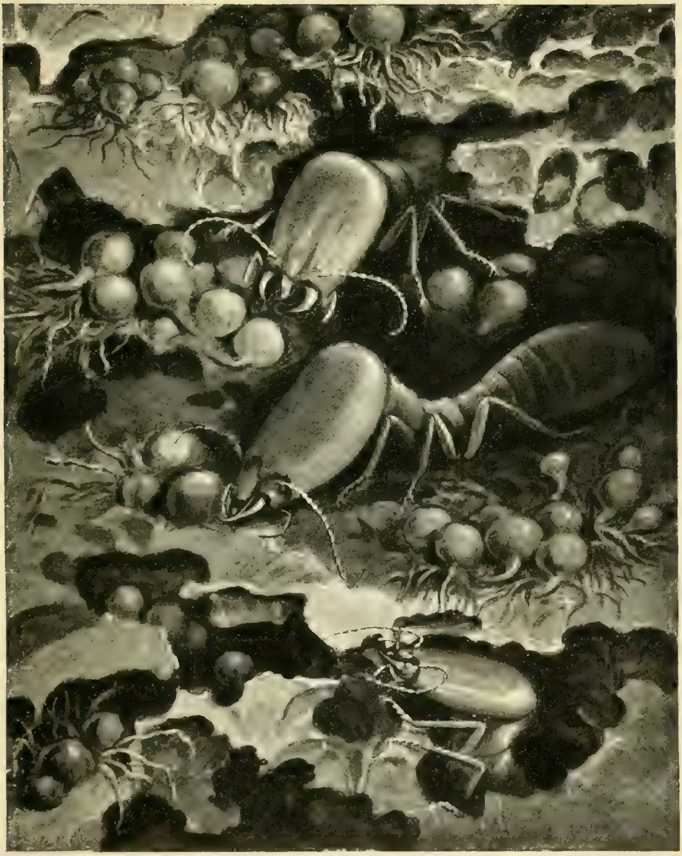

PLATE 30 TERMITES' MUSHROOM GARDEN. Page 226

The Termites or "White Ants" set apart certain chambers of their hills for the cultivation of a kind of mushroom, which they utilise for food.

Drawn by T. Carreras.

PLATE 31 SEXTONS. Page 234

A goldfinch has fallen dead, and the burying beetles, having learned the fact, have hastened to the spot. One is on the body taking in the bearings of the case, whilst another (under the wing) has already begun to dig the earth away.

Drawn by T. Carreras.

Among our wood-boring beetles we have several species of *Tomicus*. Some allied species in the United States appear at first sight to have the horticultural habit. They live in a common burrow, which is not usual with wood-boring beetles, and on the accumulations of their excrement peculiar fungi grow, which the beetles feed upon.

Hubbard says that some species do actually cultivate these fungi, and make elaborate preparations of a mushroom-bed to induce their growth. If these beetles have learned the trick from the ants, they have not learned it thoroughly. The ants keep the fungus under control by leaving air-space around their bed, and so restrict the increase of the fungus within limits. In the narrow spaces of beetle-burrows there is not room for this, so it is said that the growth of the fungus is sometimes more rapid than the eaters can keep pace with. In consequence, it plugs up the exit of the burrow so effectually that the beetles are suffocated. We think that in this case, though the beetles may avail themselves of the fungus as food, its presence is merely adventitious and not the result of anything that can be regarded as cultivation.

X

SANITARY OFFICERS

X

SANITARY OFFICERS

Long before cities were invented, with their elaborate schemes for making life possible under unnatural conditions, Nature had her sanitary commission at work to keep the earth sweet. It is still in existence; but owing to most of us having lived under urban conditions all our life, we fail to recognize the officers as such when we see them, and in most cases take offence at their presence. In the majority of cases we have only ourselves to thank for their visits, which are due to our having some nuisance or other on our premises or adjacent thereto. Looked at from Nature's point of view, if we may so express it, everything that is dead is a nuisance and a menace to the living; so it must be cleared away as soon as possible and reduced to an elementary condition in which it can be used over again in the processes of the universe.

Yes, says the citizen, but we have provided for all that in our splendid scheme of civilization. We have magnificent sewerage on which we have spent millions, scavengers and orderly brigades in the streets, house-to-house collection of refuse,

etc. True, but Nature's sanitary commission would reply that there is still much to be done. The annoying fly would not be about the house were there no refuse-heaps near by that its grubs are striving to reduce in bulk. The "blue-bottle" would not trouble to enter but for the dead animal remains in the shape of "joints," poultry, and fish in our larder. Nature's edict is that all effete matter must be reduced to an inoffensive condition.

It were idle to attempt an enumeration of the insects that are engaged in this work: their name is legion, and they serve in various branches of the work. Looking beyond the walls of the cities, out in the open spaces, not merely of our own country, but the vast thinly populated and unpopulated areas of the world, we see these small sanitary officers pursuing their vocation and keeping the world sweet. But for them it would be uninhabitable. The dead trees and herbs, dead beasts and birds, the dung of innumerable animals, all would encumber the surface, and take so long to disintegrate by mere atmospheric influence that the higher forms of life must soon cease to be.

But no sooner does any of this worn-out material fall than these sanitary officers and scavengers become aware of the fact by sight, scent, or other means, and adopt measures for its removal. Some eat it where they find it, others bury it in the earth as a preliminary to being eaten by themselves and their offspring. Some of these we have already dealt with under the head of miners—the Scarabs

and other dung-feeding beetles that dig vertical shafts for the disposal of such matter that therein their grubs may consume it in comfort and safety. There are enormous numbers of different species of beetles performing this service, our own country possessing about seventy. There is, however, no great variety in their habits; they are consumers of dung both as beetles and as grubs.

The Sexton Beetles (*Necrophorus*), though a much smaller group, are perhaps much better known as to their habits by the general public, owing to their having been often described since Gleditsch first made them known in 1752. If a dead mole, bird, frog, or other small animal be laid upon the earth, and the spot marked, it will be found after two or three days that the body has disappeared. On loosening the earth, it will be found buried at a depth of two or three inches. Two or three beetles, their rather broad backs barred with black and orange bands, may be seen somewhere on or under the corpse. These are the Sextons whose industry has interred the dead body, their object being the provision of food for their young. The female lays her eggs upon the body, and from these hatch out tiny grubs which at once fall to upon the abundant store of food provided for them, and rapidly consume it.

For the successful carrying out of this operation it is necessary that the animal has fallen dead upon tolerably soft earth. We have seen a bird that had apparently met its death by flying with great

force against the telegraph wires and had fallen dead upon the hard highway. A couple of Sexton Beetles were doing their best to make some impression upon the road, but the steam-roller had done its work too effectually. We were unable to follow what happened to that bird, but in all probability the beetles would make an effort to shift it off the road to the softer marginal land. Failing that expedient, they would be likely to make a good meal and leave it to chance.

In the case of an insect that buries such material it is in the ordinary way difficult to follow what happens. When a thing disappears from the place where we left it we are likely to ascribe its absence to anything but the actual cause; and if Gleditsch had not thought of making experiments under somewhat artificial conditions we might have waited long before learning the truth.

He placed a dead mole on one of his garden beds, where, of course, the soil was sufficiently loose for these Sextons to work. On the third morning after so placing it the mole had disappeared. Digging where it had been laid, he came upon it at a depth of three inches, and under it were four beetles. He did not attach great importance to that fact, although on examining the mole and finding nothing singular in its appearance, he thought perhaps the beetles might have been concerned in some way in the operation. So he buried the carcase again in the same grave, and left it for an interval of six days, when he found it

was swarming with grubs. These he now thought must be the young of his beetles, and jumped to the conclusion that the parents had buried the mole for the sustenance of their unborn progeny.

The surmise must be put to the test. Hunting for some of the beetles, he found four, and these he put into a covered glass vessel half filled with earth, and on the surface he placed a couple of dead frogs. Before twelve hours had passed one of these frogs had been interred by two of the beetles, whilst the other two spent a day in running over and about the remaining frog, as though taking its dimensions and estimating how deep a grave would be required. But on the third day this frog also had disappeared. Then he introduced a dead linnet, which was soon found by a pair of the beetles, and they provided him with a demonstration of their skill. They got under the bird and began scraping away the earth, and pushing it aside with their hind legs.

"It was curious to see the efforts which the beetles made by dragging at the feathers of the bird from below to pull it into its grave. The male, having driven the female away, continued the work alone for five hours. He lifted up the bird, changed its place, turned it, and arranged it in the grave, and from time to time came out of the hole, mounted upon it and trod it under foot, and then retired below and pulled it down. At length, apparently wearied with this uninterrupted labour, it came forth and leaned its head upon the earth beside

the bird without the smallest motion, as if to rest itself, for a full hour, when it again crept under the earth. The next day in the morning the bird was an inch and a half under ground, and the trench remained open the whole day, the corpse seeming as if laid out upon a bier, surrounded with a rampart of mould. In the evening it had sunk half an inch lower, and in another day the work was completed and the bird covered."

Gleditsch, having got his beetles to work in captivity, tested the results he had already obtained by adding other small dead animals, until the earth in his glass vessel must have become almost as full of remains as the soil in a cemetery. In the course of fifty days these four Sextons had buried no fewer than twelve subjects, including four frogs, three birds, two fishes, a mole, and two grasshoppers, as well as the entrails of a fish and two pieces of ox lung. Another beetle, unaided, in two days buried a mole that was forty times its own bulk and weight. These beetles always hunt in couples, but it is the male that performs the chief part of the digging.

Beetles of allied genera, though they do not bury, are quick to note the presence of dead animals and lay their eggs in them so that their larvæ can feed on the flesh and rapidly dispose of it. If one wishes to know the kinds of beetles that engage in this work, the shaking over a newspaper of any dead bird or small mammal found in the woods or fields will give him some idea of the types.

An umbrella or collecting-net held beneath the row of pigeons, hawks, owls, and stoats that the gamekeeper has nailed up as a warning to the others, whilst the victims are tapped smartly with a stick, will yield many specimens. There will be Carrion Beetles (*Silpha*), flat-backed creatures, mostly of a dead-black hue; Mimic Beetles (*Hister*), square-backed, highly polished insects, that at once pretend to be dead; Bacon Beetles (*Dermestes*), very convex, with a broad yellowish-grey band across the middle of the black back; and some of the larger of the Rove Beetles (*Staphylinus*), such as *Creophilus maxillosus*.

Space will not allow us to give any detailed description of the numerous beetles that are engaged in this sanitary work, or of the ways by which they carry it out. Some reference should be made, however, to one of them, the Bacon Beetle (*Dermestes lardarius*), because, as its popular name implies, it sometimes comes very near home to some of us in our houses, as well as attacking the "examples" that swing from the keeper's gibbet. It is, indeed, a general feeder on dead animal matter, and does not mind how dry and old it is. After the other beetles and their larvæ think that they have extracted all the nourishment from the swinging carcases, *Dermestes* can get meals for many a day from the shrivelled skins and the tough ligaments that the others have feared to spoil their jaws upon.

Naturalists sometimes have unpleasant acquaintance with this beetle, and find that some choice

specimen, whether it be in fur or feathers, horns or hoofs, has been providing nourishment for years for this terrible insect. The marvel is that it can go on feeding upon such dry pabulum without ever an opportunity to imbibe the slightest drop of moisture. It will bore right through a flitch of bacon and give it what country people call a "reasty" flavour.

Westwood informs us that years ago another member of the same genus (*Dermestes vulpinus*) inflicted such damage on skins in the warehouses of London merchants that they made a joint offer of twenty thousand pounds as a reward for the discovery of any real method of extermination. We believe the reward was never claimed. This is one of the numerous cases where Civilization comes into conflict with Nature. *Dermestes* has a commission to look especially after the hard dry parts of animal remains that have been left uneaten by blow fly gentles and carrion beetles. Here is a building full of old skins discovered by the beetles. "It's a big job," muses the mother beetle; "but it's got to be done." And she does her best by laying an abundance of eggs to execute the commission.

The skin-merchant thinks Nature has no sense to let loose such rapacious pests among his goods; but from Nature's point of view the warehouse is stacked with refuse, which must be disintegrated as quickly as possible and the elements of which it is composed put into circulation again. From Civilization's point of view Nature's sanitary officers

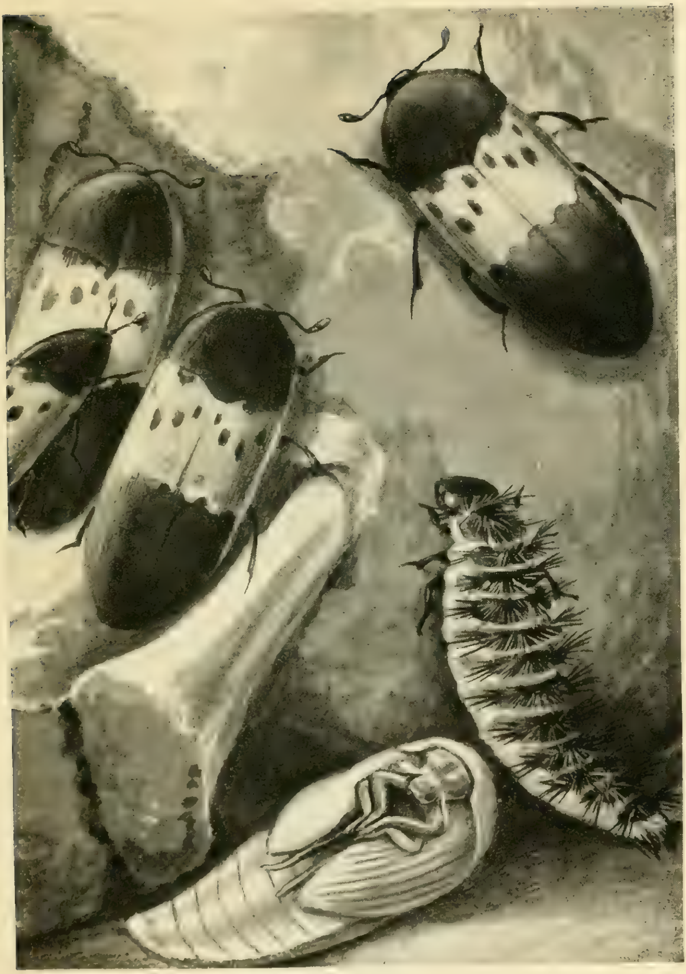

PLATE 32 THE BACON BEETLE. Page 238

In its grub stage this little beetle inflicts great damage in stores of ham and bacon. The grub is the hairy creature to the right of the picture. Below it is the chrysalis, and above several beetles. All magnified.

Drawn by T. Carreras,

Bee-like Drone-fly.

Plate 33 Girdled Drone-fly. Page 248

These flies, which have a superficial resemblance to bees and wasps, were held formerly to be parasites upon their hosts; but they are now known to be beneficent scavengers, helping to keep the nest clean.

Photos by Author.

are pests; from Nature's point of view all stored-up animal remains, whether hams, skins or feathers, fresh joints, fish or poultry, from which life has departed, are fair game for beetles, blow flies, and other scavengers. It is useless to rail against natural laws; they have been evolved not for man's convenience, but for the proper governance of the world as a whole. We must either submit to them or set our wits to work to suspend their operation so far as our property is concerned.

The naturalist has a special pest of the same tribe of beetles. From Nature's point of view the naturalist is a great accumulator of rubbish, and in consequence these sanitary officers keep a very strict eye upon him. What though he puts away his hoards in glazed cases that are guaranteed air-tight by the makers, and pins nice little blocks of camphor in the corners? The glass lids have to be lifted sometimes to take out or put in "specimens," and now and then a watchful inspector in the shape of a House Moth or a Museum Beetle contrives to drop in an egg or two—perhaps concealed in the fur of a new specimen—and when the case is inspected a few months later the operations of the resulting grub are evident.

This Museum Beetle (*Anthrenus musæorum*) is one of the most efficient of these sweepers-away of dead matter, though not when it is in the beetle stage. Then it has a fondness for the open air and fresh flowers; it is as a grub that it performs its important work.

With most insect larvæ it is imperative that—except when they are in hibernation—they should have a continuous supply of food; but *Anthrenus* is lord of his appetite. If a dry carcase is at hand he can enjoy it, and if nothing eatable presents itself he can wait with patience, adopting the equivalent of the hungry man's expedient of tightening his belt. *Anthrenus* has no distinct belt to tighten, but he throws off his too roomy skin and presumably feels more comfortable in a new and less expanded one. Then he waits, and if the prospect of a meal is still unduly far off, he moults again.

But for the bad taste exhibited by this grub in the selection of naturalists' stores for his dining-room, he would probably be considered a very interesting insect; but we do not remember to have heard him spoken of with any amount of admiration even in the heart-to-heart talks of entomologists.

His upper side is clothed with long, stiff brown hairs and the under side with shorter and paler hairs. His six long, jointed legs are fringed with similar stiff hairs. On each side of three segments of his hind body he has these hairs arranged in bundles, which are normally laid against the back, but can be erected at will. If you attempt to pick up this small grub with your finger and thumb you will find it is an impossible feat, the hairs being so arranged that it slips from your grip. This arrangement probably facilitates its passage through minute crevices and into the interior of the carcases it is destroying.

When at length it has found suitable fare it proceeds with its meal leisurely, as though it held that good things are not to be disposed of hurriedly, but in the spirit of Milton's "linked sweetness long drawn out." Anyway, it takes about a year of this discriminate feeding to bring his diminutive body to its full size, and then his skin splits down the back, but is not cast off: the chrysalis remains within the larva skin. The beetle that emerges is smaller than the grub; and a dozen of them placed end to end would only measure about an inch. Strictly speaking its colour is black, but the black is masked by minute triangular scales, some brown, others whitish, the latter arranged in three irregular bands across the back. When it gets the notion that it is advisable "to lie low" it tucks in its head and legs and is to all appearance a lifeless particle of refuse.

The sanitary officers that are best known to those who are not entomologists are the two-winged flies, especially those that make frequent calls upon us in our homes. But the public as a rule fail to recognize them in the character of officers for the removal of nuisances, insisting that they are themselves the nuisance. Of late years one very prominent member of this staff of sanitary officials has actually been accused—and with good reason—of being actively engaged in the dissemination of disease germs.

This monster—according to recent views of him—is the ubiquitous House Fly (*Musca domestica*).

The charge appears to be well founded, but though we have no desire to whitewash him, it is right that some one should act the part of "devil's advocate" and point out, with a view to mitigation of penalties, that his carrying of noxious germs is not done "of malice aforethought," and that he would not do so if the said germs were not left carelessly in his way to cling to his feet. We play all sorts of tricks with the laws of Nature, and when trouble comes of it we try to set it right in the wrong way. Here are we now founding Kill-that-Fly leagues and preaching crusades against the insect, when we ought to be clearing away the muck-heaps near our homes in which the flies are nurtured.

Nearly every man who owns a bit of garden ground is so impressed with the necessity for feeding up his plants with stable manure that he has a heap handy for the purpose, and a smaller heap at the roots of every rose-bush. In some cases he has applied it so continuously that the surface soil of the whole garden is largely composed of it. Then the flies come as Nature's sanitary officers and decide that it must be reduced to an inoffensive condition.

Every female fly lays about a hundred and twenty eggs on it, and these hatching in a day or two, the maggots set to work with all speed to reduce the nuisance. In less than a week they have done what they could, have become full-grown, and in another week they are flies. They lay their eggs, thus ensuring the continuation of the sanitary

work by a vastly increased host of workers, and then, attracted by various odours, enter our dwellings for a brief life of enjoyment, partaking of infinitesimal portions of our food, licking up the microbes we foster but do not want, and perhaps coming to an end in the milk-jug or the jam-dish.

It must not be supposed from what has been said that the House Fly confines its attention to the heap of stable-manure as an egg-laying ground and nursery for its progeny. It feeds in any organic waste that is sufficiently warm and moist to ferment, but mainly in horse manure, human manure, pig manure, spent hops and malt-waste (brewer's grains). Each female fly lays several batches of eggs, in all about six hundred, which hatch in periods varying with the conditions at the time—often eight hours, sometimes four days. The newly hatched "maggot" at once burrows into the mass of refuse, seeking the moister parts that he may feed upon the liquid portion. The most favourable temperature for development appears to be between 90° to 98°.

Dr. L. O. Howard, who has written a terrible indictment of the House Fly—which he prefers to call the Typhoid Fly—has made a calculation of the progeny of a single female fly that, having passed the winter in some snug spot, begins laying eggs on April 15. By September 10 the living issue of that fly will be 5,598,720,000,000! Of course, in fact, all the eggs laid do not produce maggots, all the maggots hatched do not survive

to become flies, all the female flies do not become mothers; but to eliminate failures of this sort he reckons that half a generation consists of females and that each female lays only 120 eggs instead of her maximum 600.

He shows that in the United States, at least, typhoid, cholera infantum, and "summer complaint" are chiefly spread by these flies carrying the germs from the sick to the well. Most other complaints that flesh is supposed to be heir to are greatly assisted in their spread by the same agency. Several English authorities on sanitation have made similar declarations as the result of their investigations.

Many of these creatures are a sort of Jekyll-and-Hyde combination of two personalities, here, however, marking two successive phases of existence. The question is which is the greater, the harm or the good they do? The answer for the individual may be the harm, whilst for the race it is probably the good. Any way, the rational course is to clear away the cause, and the effects must cease. The stable is rapidly becoming an institution of the past. Let the suburban gardener anticipate the early date when it will have ceased to be by feeding his garden with chemical manures.

But one of our House Flies (*Homalomyia canicularis*)—a somewhat smaller and paler insect than the other—feeds in its larval days on decaying *vegetable* refuse, so the garden rubbish should be burnt, not stacked. This fly has more rounded

tips to its wings, and on account of its inferior size is often referred to as a *young* House Fly. Size in the case of insects that have reached the winged stage, it is perhaps unnecessary to point out, is no criterion of age. This stage reached, growth almost invariably ceases.

The food of the Blue-bottle or Blow Fly (*Calliphora vomitoria*) in its grub stage is very different. It is a flesh-feeder, and its proper mission in life is to clear away those animals that have met with death from old age, disease, or in an encounter with an opponent. That mission is undoubtedly an important and beneficial one for the human race, but when that race takes to storing meat, poultry, and fish in its larders, and the keen senses of the Blow Fly track it to its hiding-place, some fault is found with Nature's arrangements. What seems to be required of Nature to meet the altered conditions brought about by civilization is the evolution of a race of Blow Flies that can distinguish between what is common and what is property. The vegetarian comment upon this suggestion would be that it would be more reasonable to give up converting our larders into charnel-houses!

The truth is, that what we dub domestic pests are part of the price we have got to pay for our domesticity. All the Kill-that-Fly leagues can do will make no appreciable difference to the fly nuisance; and probably if we were to pull down our houses and return to the pastoral life of our nomad forefathers we should find we had only

got rid of the attentions of one class of pests to fall under the care of another group. Even Mrs. Troglodyte-Smith must have found that there were undesirable creatures who insisted upon sharing her cave.

Some of these sanitary or scavenger flies, though their habits in the larval stage are similar to those of the Blow Fly, rarely or never enter our houses, and therefore do not become a nuisance to us. Such are the Green-bottle (*Lucilia cæsar*) and the Flesh Fly (*Sarcophaga carnaria*). The first does occasionally wander into open windows and doors in the summer, but does not stay in the house, preferring to sit on leaves in the hottest sunshine and exhibit its shining golden-green livery to the best advantage.

The Green-bottle is the special bane of the fishmonger, and if by chance we pass by the back premises where this tradesman temporarily stores his refuse, we shall startle up a cloud of these beautiful but repulsive insects, who have been engaged not only in depositing eggs in the offal, but in sucking up the more fluid decomposing portions.

The Flesh Fly is similar to the Blow Fly, but rather longer and of a grey-and-black coloration instead of the steely blue which has given the name of Blue-bottle to *Calliphora vomitoria*. It is a carrion feeder, but out-of-doors, and it retains its eggs until they are hatched, so that on the discovery of suitable material for their deposit the sanitary work of clearing away dangerous matter

begins at once. In this connection it is worthy of note that these flies have had all the details of their life-history adapted to the necessities of the case. A heap of stable manure is less inimical to animal life than is decomposing flesh, and as innumerable beetles and flies help to clear it away, the fecundity of the House Fly is not nearly so high as that of the Blue-bottle and Flesh Fly, whose work must be done much more expeditiously.

We have mentioned that the House Fly lays about 600 eggs; the Blue-bottle lays from 500 to 1,000, but dissection has shown that the Flesh Fly is able to deposit as many as 20,000 grubs. Of course, these are not all deposited at once, or in the same mass of corruption: they are laid in batches as appears to be necessary. But it frequently happens that a number of egg-laden Blue-bottles or Flesh Flies will lay their eggs in the same mass of food, which may not be sufficient to bring so vast an army of maggots to their full size. In that case some would feed on their weaker kindred, so that some could come to maturity and continue the race. The dead matter would become converted rapidly into living matter, and so cease to pollute the atmosphere; but the futility of attempting to get rid of the fly-nuisance by killing a few thousand flies here and there is apparent. It is akin to trying to empty the ocean with a tea-spoon.

In addition to these sanitary officers whose commission may be said to be rather general—to clear away nuisances of a certain kind wherever they

may be found—there are other flies whose functions are more narrowly defined—what one might term sanitary specialists. Such are the Bee Flies (*Volucella*) which were long thought to be parasites on bees and wasps, because their larvæ and pupæ were often found in the nests of Humble Bees and wasps underground. Instead of parasites they are commensals—companions who give as well as receive. They are not of the highest order of commensals, those that are cherished by their hosts; these appear to be only tolerated, as though the nest-owners have only a dim perception of the importance of the duties *Volucella* performs.

In exploring wasps' nests at the end of the season when the colony has practically come to an end, we have found a great number of *Volucella* larvæ crawling about the combs and thrusting their narrow heads into the depths of the cells. When a wasp-grub comes to the winged condition and quits the cell it leaves behind at the bottom (top as the wasp sees it, for the cells are all inverted) a thick black cake composed of the grub's excrement and cast skins. It is doubtful if a wasp could clean this out to make the cell fit to receive an egg and to cradle another grub: the wasp's head is too broad to reach the bottom.

This is where the services of the *Volucella* grub come in. Its body, though broad behind, narrows to the front, and the head is quite small. He reaches to the end of the cell and feeds on its objectionable contents, making it fit for another

occupant. Examination of the combs shows a large number of grubs of all sizes engaged in this work. These remarks apply to *Volucella pellucens*, which we have found so engaged in the underground nests of *Vespa germanica*, a common wasp. Other species are attached to other species of wasps and to distinct species of Humble Bees.

The best-known species of *Volucella* is *V. bombylans*, whose hairy body has a general resemblance to a Humble Bee, and it is interesting to note that in early life it lives in the nests of various species of Humble Bees. In former days, not long ago—when these flies were regarded as parasites—the resemblance to a Humble Bee was held to have been acquired specially to enable it to enter the bee's nest to lay eggs without its real character being suspected; but, seeing that *Volucella pellucens* does not resemble a wasp in the remotest manner, this theory will not hold good, for this species should stand more in need of such protection than *V. bombylans*, because the wasps prey very largely upon the two-winged flies, whilst Humble Bees are not insectivorous at all.

However, mimetic resemblance does not come within the scope of our present inquiry. The grubs of *V. bombylans* clean out the vacated cocoons of the Humble Bees and make them available for the storage of pollen; they also eat up the debris that collects under and around the irregular comb, and so help to keep the nest sweet.

XI

MUSICIANS

XI

MUSICIANS

Of a few Insect Musicians it may be said that their power of producing sounds has been notorious ever since the beginning of time. Some have regarded these sounds as music, others as a wearying noise, and they will continue probably to be so diversely regarded according to the temperament or the condition of health of the hearer. The writer, being a person of mild disposition and optimistic tendency, has boldly classed them all as Music, and in so doing feels that he has the great body of the poets with him.

The poets—and others—it must be admitted have made mistakes about this music. Some have thought the insects had real vocal apparatus, others that the sounds were produced solely by rapid wing vibration. But, as one would expect to find among creatures of such varied organization, a similar end is reached by different means. Some have a real vocal apparatus, though not connected with the mouth; but in most cases it is more akin to the action of lyre and plectrum.

The list of Insect Musicians is far too long to be

dealt with in detail: we can only pick out, almost at random, a few representative species and describe, not too minutely, the nature of their sounds and how these are produced. The species most celebrated for its song from antiquity is the Cicada, concerning which the Greek poet, Xenarchus, wrote the ungallant couplet that has been quoted almost *ad nauseam*, possibly ever since it was written:

> "Happy the Cicadas' lives,
> For they all have voiceless wives."

The Cicada stands apart from all other insects, indeed from all other animals, in the character of its voice-box. It is not here a case of scraping one file on another, or a file on a drum. There is a special cavity in the thorax, divided into chambers by membranes of different character, and a specially delicate drum or tymbal which is set vibrating by the insect to produce the initial sound. These vibrations are caught up and intensified by the other membranes and the two opercula or shields which cover the entire apparatus on the under-surface of the insect.

Landois was of opinion that the sound was produced by the lips of the spiracles or external openings of the air-passages, vibrating as a current of air was forced through them by the air-tubes. More recently, Powell showed that, though the spiracles may influence the volume of sound by regulating the tension of the air in the chambers, the vibrations are those of the tymbal, set in motion

by a special muscle. These vibrations can be watched in the living insect when it is singing.

The present writer is indebted to the Rev. R. Wyllie, for further light upon the method by which the vocal apparatus is set vibrating. This gentleman spent twenty years in Guiana and set himself to elucidate the matter. He says :—

" The insect is called the ' Six o'clock,' because it is always heard about the time of sunset, which occurs about six o'clock all the year round. In Trinidad, I believe, it is called the ' Scissor Grinder,' because its noise resembles that made by a few score scissor grinders concentrated in one loud effort. The insect may be heard at other times, especially at sunrise and noon ; but not so persistently.

" In answer to my enquiries, I could find no one to tell me how the great noise was produced by so small a creature. For years my curiosity on the subject was unsatisfied. ; although I persevered in both enquiries and observations. Two things I had noted : first, that the long shrill note, lasting about twenty to thirty seconds, was preceded by three or four short jerky ones ; and, second, that the distance and direction were not easily judged. A cicada might seem to be uttering its call at a distance of fifty or a hundred feet away, on the right, and suddenly the little creature would stop, and fly away from a position within arm's length, on the left.

" And then, one evening as I was standing still,

watching something else, my attention was arrested by the short quick notes of a cicada within a few inches of my eyes. To my delight I saw the insect distending its abdomen with each short note. Then as it produced the long note I saw the abdomen gradually contract, as if the air that had been pumped in was being expelled with great muscular force. Just before the long note was finished, I was fortunate enough to catch the little fellow in my hand; and then to my further delight and surprise, I found that by gently pressing the thorax, I could secure an encore at will. This lasted nearly all the time I was walking home; and I was able to watch the distention and contraction of the abdomen for nearly half an hour—long after the other cicadas had ceased their song for the evening.

"The conclusion I reached, in conjunction with what I have read on the subject, was that the cicada is able to fill the abdominal space with compressed air, and then force this air through the tympanum. (Note the accordion-like structure of the abdomen) . . . I had few other opportunities for watching the cicadas quite as good as this first one, but whenever I had the opportunity I was convinced of the correctness of my observations on that occasion."

Respecting the silence of the females, which attracted the attention of Xenarchus, it is not due to want of the apparatus, but to the fact that it is not fully developed.

Hartman speaks of the music as the "marital

PLATE 34 THE CICADA'S MUSIC-BOX. Page 256

A Cicada seen from below. The arrow points to the position of a pair of convex shields, beneath which are the complicated timbals and membranes which produce the shrill sounds.

Photo by Author.

PLATE 35 GREAT GREEN GRASSHOPPER. Page 266

One of the long-horned section. The example photographed is a female, and, like all the females of its family, silent; but the male has the most powerful "voice" of all British insects. The sound is produced by rubbing one wing-cover over the other.

Photo by Author.

summons from the males." Fabre ridicules this notion. He says where males and females feed together on the same twigs there is no need for shrill calls to inform the latter where she will find the former. This is how he puts it, after describing the common *Cigale* of Provence ranged in rows on the branches of the trees, the two sexes mingled and only a few inches apart. "One does not spend months in calling a person who is at one's elbow. Moreover, I have never seen a female rush into the midst of even the most deafening orchestra. Sight is a sufficient prelude to marriage, for their sight is excellent. There is no need for the lover to make an everlasting declaration, for his mistress is his next-door neighbour. Is the song a means of charming, of touching the hard of heart? I doubt it. I observe no sign of satisfaction in the females; I have never seen them tremble or sway upon their feet, though their lovers have clashed their cymbals with the most deafening vigour."

Darwin says that when the *Beagle* was anchored at the distance of a quarter of a mile from the shores of Brazil, "the noise thus made could be plainly heard on board," and Captain Hancock stated that it could be heard at the distance of a mile. It will be noted that Darwin does not allude to it as a musical sound, but a noise, and this is perhaps justified by a remark of Bates, who was probably referring to the same species, for he was in the same region.

Describing the "terrible discord" of mingled

noises set up at sunset by birds and monkeys, the latter naturalist says: "Added to these noises were the songs of strange Cicadas, one large kind perched high on the trees around our little haven, setting up a most piercing chirp; it began with the usual harsh jarring tone of its tribe, but this gradually and rapidly became shriller, until it ended in a long and loud note resembling the steam-whistle of a locomotive engine. Half a dozen of these wonderful performers made a considerable item in the evening concert. I had heard the same species before at Pará, but it was there very uncommon."

Concerning the American species known as the Seventeen-year Locust (*Cicada septemdecim*), there is an extraordinary feature in its life-history which, though it has nothing to do with its character as a musician, we feel justified in mentioning. It is widely spread over the greater part of the United States, but in any given locality it only makes its appearance in considerable numbers once in seventeen years. Kalm was the first to call attention to this fact, but his statement appears at first to have been regarded with doubt; subsequent investigations, however, established the fact, and reasons were sought for the periodicity.

It is now shown that the insect takes nearly seventeen years—in some States, when the seasons are more uniformly favourable, thirteen years—in its progress from the egg to the acquisition of expanded wings. During this long period, which

entitles this Cicada to be considered the Methusaleh of insect-life, it is underground sucking at roots, and is unseen. The eggs are laid in slits made by the females in the stems of shrubs, and the newly hatched grub burrows into the ground.

Owing to the rapid changes that take place in the United States, places that were woods or open prairies when the Cicada's eggs were laid are flourishing cities before the seventeen-year cycle is complete, and some of the poor Cicadas have been known to emerge into cellars instead of the open air; whilst it is fair to assume that many never emerge at all because the place of their interment has been sealed by laying concrete floors.

Reverting to the musical abilities of these insects, it should be pointed out that there is considerable difference apparently in the character of the sounds produced by American Cicadas and those of Europe. Concerning the latter, the ancient Greeks kept them in cages for the sake of their songs, and Kirby and Spence have a paragraph which is worth quoting in this connection. Cicadas, they declare—

"Seem to have been the favourites of every Grecian bard from Homer and Hesiod to Anacreon and Theocritus. Supposed to be perfectly harmless, and to live only upon the dew, they were addressed by the most endearing epithets, and were regarded as all but divine. One bard entreats the shepherds to spare the innoxious *Tettix*, that nightingale of the Nymphs, and to make those

mischievous birds the thrush and blackbird their prey. 'Sweet prophet of the summer,' says Anacreon, addressing this insect, 'the Muses love thee, Phœbus himself loves thee, and has given thee a shrill song; old age does not wear thee out; thou art wise, earth-born, musical, impassive, without blood; thou art almost like a god.'

"So attached were the Athenians to these insects, that they were accustomed to fasten golden images of them in their hair, implying at the same time a boast that they themselves, as well as the Cicadæ, were *Terræ filii*. They were regarded indeed by all as the happiest as well as the most innocent of animals. . . .

"If the Grecian *Tettix* or *Cicada* had been distinguished by a harsh and deafening note, like those of some other countries, it would hardly have been an object of such affection. That it was not is clearly proved by the connection which was supposed to exist between it and music. Thus the sound of this insect and of the harp were called by one and the same name. A Cicada sitting upon a harp was a usual emblem of the science of music, which was thus accounted for: When two rival musicians, Eunomus and Ariston, were contending upon that instrument, a Cicada flying to the former and sitting upon his harp supplied the place of a broken string, and so secured to him the victory.

"To excel this animal in singing seems to have been the highest commendation of a singer; and

even the eloquence of Plato was not thought to suffer by a comparison with it. At Surinam the noise of the *Cicada tibicen* is still supposed so much to resemble the sound of a harp or lyre, that they are called there harpers (*Lierman*). Whether the Grecian Cicadæ maintain their ancient character for music, travellers do not tell us."

The Romans appear to have differed from the Greeks in their appreciation of this music, for Virgil in his Georgics accuses his native Cicadas of bursting the very shrubs with their noise, and he is supported by the comparatively modern Sir J. E. Smith, who says it "makes a most disagreeable dull chirping." Dr. Shaw, again, alluding to the Seventeen-year Cicada, says:

"In the hotter months of summer, especially from midday to the middle of the afternoon, the Cicada, *Tettix*, or grasshopper, as we falsely translate it, is perpetually stunning our ears with its most excessively shrill and ungrateful noise. It is in this respect the most troublesome and impertinent of insects, perching upon a twig and squalling sometimes two or three hours without ceasing; thereby too often disturbing the studies, or short repose that is frequently indulged in in these hot climates, at those hours. The *Tettix* of the Greeks must have had quite a different voice, more soft, surely, and melodious; otherwise the fine orators of Homer, who are compared to it, can be looked upon as no better than loud, loquacious scolds."

In our own day C. V. Riley, the late State Entomologist, thus refers to the Seventeen-year Cicada: "The general noise, on approaching the infested woods, is a combination of that of a distant threshing-machine and a distant frog-pond. That which they make when disturbed mimics a nest of young snakes or young birds under similar circumstances—a sort of scream. They can also produce a chirp somewhat like that of a cricket and a very loud, shrill screech prolonged for fifteen or twenty seconds, and gradually increasing in force and then decreasing."

The order of insects (Orthoptera) which, next to the Cicada, has been most celebrated for the production of sounds contains the Crickets and Grasshoppers; and these produce their shrill cries in quite another manner, the instrument being more akin to the fiddle and bow. Yet even here there is a great amount of variation in the method of employing the same principle. In the three families, Gryllidæ (Crickets), Locustidæ (not Locusts), and Acridiidæ (Grasshoppers and Locusts), differences of structure necessitate differences in the fiddles and bows.

The song of the House Cricket (*Gryllus domesticus*) is produced by the wing-covers (*tegmina*) of the male insect. On the under side is a file, and as the pair are vibrated the edge of one scrapes the file on the other and produces the shrill "crink-crink." Bates speaks of a species of Wood Cricket he calls *Chlorocœlus tananá* (more correctly found to be

Thliboscelus camellifolius), he met with in the neighbourhood of Obydos, Brazil. He says:

"The notes are certainly the loudest and most extraordinary that I ever heard produced by an orthopterous insect. The natives call it the Tananá, in allusion to its music, which is a sharp, resonant stridulation resembling the syllables "ta-na-ná, ta-na-ná," succeeding each other with little intermission. It seems to be rare in the neighbourhood. When the natives capture one, they keep it in a wicker-work cage for the sake of hearing it sing. A friend of mine kept one six days. It was lively only for two or three, and then its loud note could be heard from one end of the village to the other."

It is not a true Cricket in spite of its name, but a member of the Locustidæ, which are intermediate between the Crickets and the Grasshoppers.

"The total length of the body is two inches and a quarter; when the wings are closed, the insect has an inflated vesicular or bladder-like shape, owing to the great convexity of the thin, but firm, parchmenty wing-cases, and the colour is wholly pale green.

"The instrument by which the Tananá produces its music is curiously contrived out of the ordinary nervures of the wing-cases. In each wing-case the inner edge, near its origin, has a horny expansion or lobe; on one wing this lobe has sharp raised margins; on the other the strong nervure which traverses the lobe on the other side is crossed by a number of fine sharp furrows like those of a file

When the insect rapidly moves its wings the file of the one lobe is scraped sharply across the horny margin of the other, thus producing the sounds; the parchmenty wing-cases and the hollow drum-like space which they enclose assisting to give resonance to the tones.

"The projecting portions of both wing-cases are traversed by a similar strong nervure, but this is scored like a file only in one of them, in the other remaining perfectly smooth. Other species of the family to which the Tananá belongs have similar stridulating organs, but in none are these so highly developed as in this insect; they exist always in the males only, the other sex having the edges of the wing-cases quite straight and simple."

He proceeds to give a brief description of the variations in this apparatus in the other families, which is so terse that it is worth quoting further:

"In the common Field Cricket of Europe the male has been observed to place itself, in the evening, at the entrance of its burrow, and stridulate until a female approaches, when the louder notes are succeeded by a more subdued tone, whilst the successful musician caresses with his antennæ the mate he has won. Any one, who will take the trouble, may observe a similar proceeding in the common House Cricket.

"The nature and object of this insect music are more uniform than the structure and situation of the instrument by which it is produced. This differs in each of the three allied families above

mentioned. In the Crickets the wing-cases are symmetrical; both have straight edges and sharply scored nervures adapted to produce the stridulation. A distinct portion of their edges is not, therefore, set apart for the elaboration of a sound-producing instrument. In this family the wing-cases lie flat on the back of the insect, and overlap each other for a considerable portion of their extent.

"In the Locustidæ the same members have a sloping position on each side of the body, and do not overlap, except to a small extent near their bases; it is out of this small portion that the stridulating organ is contrived. Greater resonance is given in most species by a thin transparent plate, covered by a membrane, in the centre of the overlapping lobes.

"In the Grasshoppers (Acridiidæ) the wings meet in a straight suture, and the friction of portions of their edges is no longer possible. But Nature exhibits the same fertility of resource here as elsewhere; and in contriving other methods of supplying the males with an instrument for the production of call-notes indicates the great importance she attaches to this function. The music in the males of the Acridiidæ is produced by the scraping of the long thighs against the horny nervures of the outer edges of the wing-cases; a drum-shaped organ placed in a cavity near the insertion of the thighs [of the hind legs] being adapted to give resonance to the tones."

The fact that these musical sounds are produced only by the males in most of the Orthoptera as in the Cicadas will prepare the reader for the further statement that they are used in the courtship of the insect, the whereabouts of the male being thus advertised to the female as in the case of the Field Cricket mentioned by Bates. There is reason to believe that some species which appear to be without musical calls of this character really have them, though the notes they produce are not audible to the human ear. The reason for this supposition lies in the fact that such apparently dumb species are provided, like the obviously musical ones, with ears, situated in their hind bodies in this family.

Every field naturalist must know from his own observation that there are people, apparently with normal powers of hearing, to whom the fiddling of a field full of grasshoppers makes no impression upon their auditory organs; and it is therefore reasonable to suppose that there may be sounds produced by insects that are not audible by the most highly developed of human ears. The possession of ears by an apparently dumb species is good presumptive evidence that that species must itself produce sounds. It should be noted, too, that each species has its own particular notes, to which, no doubt, its ears are specially attuned.

On this point Scudder, speaking of North American grasshoppers, says: "The uniformity with which each species of *Stenobothrus* plays its own

song is quite remarkable. One kind, *Stenobothrus curtipennis*, produces about six notes per second, and continues them from one and a half to two and a half seconds; another, *S. melanopleurus*, makes from nine to twelve notes in about three seconds. In both cases the notes follow each other uniformly, and are slower in the shade than in the sun."

These, as in all the Grasshoppers (Acridiidæ), produce their sounds by scraping the hind leg over the projecting nervures of the wing-covers. Harris, another American naturalist, told us long ago how this is accomplished: the male, he says, "bends the shank of the hind leg beneath the thigh, where it is lodged in a furrow designed to receive it, and then draws the leg briskly up and down. He does not play both fiddles together, but alternately, first upon one and then on the other."

In the South African species of this family—*Pneumora scutellaris*—there is an extraordinary development of the hind body of the male, and the wing-covers are not used in sound-production. The hind body is inflated with air so as to become a great pellucid bladder, in order to increase the resonance of the sounds the insect makes by scraping the comparatively small hind legs over a series of ridges which are placed on each side of the inflated abdomen. At night these insects make a wonderful noise, according to Mr. Trimen.

Another extraordinary example from South Africa is *Methone anderssoni*, which is wingless in both sexes, and does not use its leaping legs for leaping.

The thighs are greatly expanded, and on their inner face, near to the base, three are peg-like projections. Although there are no wings, there are incipient wing-covers, and these in the male are strongly grooved and ridged, whilst below them, on the first segment of the hind body and partly overlapping the second, there is a swollen plate with two or three strong and hard folds. Just behind it, on the second segment, is a prominent area whose surface is marked by very fine raised lines. Both sexes have these arrangements, but in the male they are more highly developed than in the female. The thigh is rubbed over these sculptured plates, and the action results in a loud note. It is believed that the male can produce two distinct notes, one agreeing with that of the female, and one peculiar to its own sex.

It is a very sedentary creature, and its colouring makes it appear like a clod of earth. When molested it does not rely upon its feeble powers of locomotion for escape, but upon its capacity for making a noise which will alarm its enemy.

The long-horned Green Grasshoppers of the family Locustidæ—which, it must be again pointed out, contains no Locusts—produce their music by means of the wing-covers alone; and as these only slightly overlap at their bases, the production of a considerable volume of sound seems at first sight not very probable. Yet any one who has heard one of these insects giving expression to its joy, as we may fairly consider it, must admit that

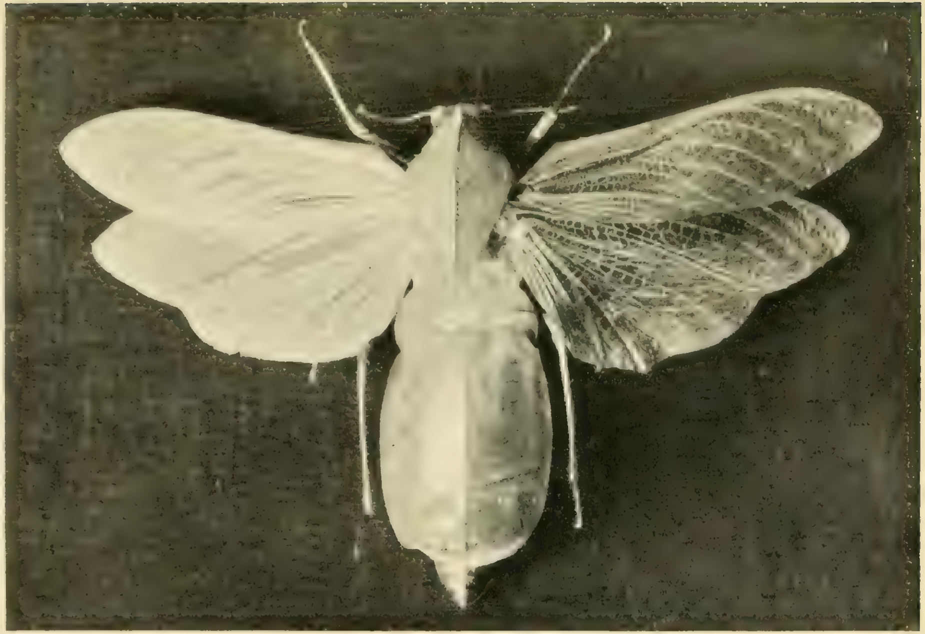

PLATE 36 THE FLYING GOOSEBERRY. Page 263

In the South African genus Pneumora, the males have the hind-body so inflated with air that they become pellucid and are known as Flying Gooseberries. There are ridges along the sides, and on scraping the hind-legs over these, sounds are emitted which are greatly intensified by the resonance of the hind-body.

Photo by Author.

PLATE 37 — A KATYDID. — Page 270

This insect, known as the laurel-leaf Katydid, is a type of the most musical of the American grasshoppers. Its shape, the uniform rich green colour, and the veining of the wing-covers are such as to render it almost invisible when among leaves.

the volume of sound proceeding from so small a creature is marvellous.

We have kept our native Green Grasshopper (*Locusta viridissima*) as a pet, feeding it upon flies, and in the evenings it sang with notes that resounded through the house. In this family the ears are placed in the front legs, a little below the knee.

De Geer pointed out long ago that an eye-like spot in the right wing-cover of the male was probably connected with the powerful note of this species. This area consists of transparent membrane "resembling a little mirror or piece of talc, of the tension of a drum. This membrane is surrounded by a strong and prominent nervure, and is concealed under the fold of the left elytrum, which has also several prominent nervures answering to the margin of the membrane. There is every reason to believe that the brisk movement with which the grasshopper rubs these nervures against each other produces a vibration in the membrane augmenting the sound. The males in question sing continually in the hedges and trees during the months of July and August, especially towards sunset and part of the night. When any one approaches they immediately cease their song."

It is to this family of long-horned grasshoppers that the famous American Katydids belong. We use the plural form, because there are several different species, and they do not all belong to the same genus. They agree in uttering sounds that

resemble the words "Katy did," with variations. Riley says that the first notes of *Microcentrum retinerve* are heard about the middle of July, and by the first of August the insect is in full song. He describes the production of the notes as follows:

"The wing-covers are partially opened by a sudden jerk and the notes produced by the gradual closing of the same. The song consists of a series of from twenty-five to thirty raspings as of a stiff quill drawn across a coarse file. There are about five of these raspings or trills per second, all alike, and with equal intervals, except the last two or three, which, with the closing of the wing-covers, run into each other. The whole strongly recalls the slow turning of a child's wooden rattle, ending by a sudden jerk of the same; and this prolonged rattling, which is peculiar to the male, is invariably and instantly answered by a single sharp 'chirp' or 'tschick' from one or more females, who produce the sound by a sudden upward jerk of the wings."

Scudder says they have two songs; one they sing by day, and the other at night. He says that the passing of a cloud will cause them to break off in the middle of the day-song and suddenly start the night-song, and that by imitating either by day you can get a suitable response from them, but at night they have only one song.

Harris says of another species, *Cyrtophyllus concavus*, that it mounts to the topmost twigs of the trees in the evening, beginning "his noisy babble,

while rival notes issue from the neighbouring trees, and the groves resound with the call of *Katy-did-she-did* the livelong night."

We have already mentioned that the too familiar House Cricket (*Gryllus domesticus*) has, in the male, a musical file on the under side of each wing-cover; and this is a character that will be found throughout the family Gryllidæ, to which it belongs. In the Mole Cricket (*Gryllotalpa vulgaris*) the musical organs are smaller and simpler than those of the House Cricket, and the note produced by them is a dull jarring note which has been compared to that of the Nightjar.

Kirby and Spence say that they once traced a Mole Cricket to its burrow by means of its song. This is a hint to those who live in neighbourhoods where it abounds, and who would like to make acquaintance with this remarkable insect. In the case of the other musical Orthoptera, we have always experienced a difficulty in following up a clue of this sort, as, to our ears, the notes often appear to have a ventriloquial quality which confuses one respecting the spot from which it arises.

Of the Field Cricket (*Gryllus campestris*) our old friend Gilbert White tells us that "they chirp all night as well as day from the middle of the month of May to the middle of July; and in hot weather, when they are most vigorous, they make the hills echo, and in the stiller hours of darkness may be heard to a considerable distance. In the beginning of the season their notes are more faint and inward;

but become louder as the summer advances, and so die away again by degrees."

What has been stated above must serve to illustrate the musical powers of the Orthoptera, which are the leading songsters of the Insect World. Let us glance at another order whose music has more of the character of that produced by the drone of the bag-pipes or by certain pipes of the organ. The music of the bees—particularly of the Humble Bees—has been understood generally to be due to the rapid vibration of the wings. On the other hand it has been contended that the sound is due to the rush of air from the air-pipes (*tracheæ*) through the spiracles or breathing-holes that are found at intervals along each side of the body.

There have been advocates and opponents of each view, but, as often happens in other fields of inquiry, the true explanation seems to lie between the two. The spiracles of the thorax (the fore body to which the legs and wings are attached) open into an enlarged chamber, which is a dilation of the air-pipe, and in which certain hard bodies are vibrated which produce the sound; the vibration of the wings increases it.

If one lifts the mossy dome from a surface nest of Humble Bees in order to see what is going on, several of the bees will throw themselves on their backs in order to be in a good position to use their stings on the intruder. In such a position there is not much beating of the air by the wings, but

the bee gives expression to her resentment by a continuous angry hum. Burmeister, not content with obtaining information in this way, cut off the wings of bees, and found that they still hummed; on the other hand, when he closed the openings to the thoracic sounding-box the hum became so feeble as to be scarcely perceptible. John Hunter found that when he held a bee under water the latter vibrated in the immediate neighbourhood of these openings.

The "buzz" of the Blue-bottle and other two-winged flies is of the same character. Although this sound-box is in communication with the breathing apparatus, it does not appear that the sounds are produced by the passage of air, but by means of muscular movements of the hard matters in the sound-box.

Pérez and Bellesme have distinguished two separate sounds in the hum of a bee—a deep note due to the vibration of the wings, and a more acute sound proceeding from the vibration of the walls of the thorax. We have thus an explanation of how insects can hum when their wings are at rest—as in an observation by the Rev. J. Hellins on the large yellow-banded fly *Sericomyia borealis*, which he found at rest among the tors of Dartmoor. He says: "Before long a piping sound was audible, and one of the party said the wind was whistling; but to this explanation I demurred, having some recollection of having heard the noise before; so, looking round, I soon saw several large flies resting

on the stones, and was presently able to convince my friend that the sound came from them."

Many insects make minor sounds, perceptible only to their own kind or to observers who come into pretty close touch with them. Such is the stridulating of ants, which is effected by the segments connecting the thorax and the hind body. Many of the beetles also stridulate, but they do not produce notes comparable in volume with those of the Cicadas and the Grasshoppers. The apparatus varies a good deal.

The large tropical beetles known as Passalids, though they are without such apparatus in the perfect state, possess it as larvæ. The basal joint of the second pair of legs bears a broad file-like area, and the third pair of legs is much reduced in size and paw-like, with hard finger-like points which scrape the file and so produce sounds. The use of this power to the insect is unknown. The most probable explanation we can suggest is, that as the larvæ feed in decaying wood, the sounds may be useful in enabling them to avoid cutting across each other in their boring operations. The grub of our Stag Beetle (*Lucanus cervus*), also a wood-feeder, has a similar arrangement.

Several other of our native beetles have stridulating organs, among them *Trox sabulosus*, one of the carrion-chafers. On the upper side of the last ring but one of the hind body there are two raised lines, and on the under side of the wing-covers there are two file-like ribs. By movements

of the hind body these are made to play over each other, and the result is a mouse-like squeak which might cause an astonished bird to drop it in alarm. The Dung Beetles (*Geotrupes*) effect a similar note by rubbing a file that is on the base of the hind legs over a ridge on the lower side of the hind body; and the larva has a contrivance similar to that described in the Stag Beetle, etc.

In the Burying Beetles (*Necrophorus*) there are a couple of parallel rasps on the upper surface of the hind body, and these are scraped by the hind margin of the wing-covers. *Pelobius tardus*, one of our water beetles, is known to dealers in aquarium stock as the Squeaker, on account of the noise it makes by scraping the horny tip of the hind body across a file along the inner margin of the wing-covers. Dr. Russel Wallace informed Darwin that *Euchirus longimanus* "makes, whilst moving, a low hissing sound by rubbing its hind legs against the edges of the elytra" (wing-covers).

The Asparagus Beetle (*Crioceris asparagi*), and *Clythra quadripuncta*, whose grub has been referred to as a Tailor, are among the beetles that stridulate; so are many of the long-horned wood-boring beetles, which emit sound by rubbing the first segment of the thorax against a special area on the next segment; others rub the thigh of the hind legs against the edge of the wing-covers.

Butterflies and moths do not shine as Musicians. They are mute insects; but at least one—the Death's-head Hawk Moth (*Acherontia atropos*) emits

a loud, plaintive squeak, which has probably added considerably to the awe which its large size and grim ornamentation have inspired in nervous persons. Various theories have been propounded in explanation of this power; but there can be little doubt that Rossi's statement is the correct one—that it is due to air being forced through the short proboscis from special air-sacs, which may be found by dissection of the moth. Similar sounds are produced by the caterpillar and chrysalis.

A South American butterfly, *Ageronia feronia*, makes a peculiar clicking noise, "similar to that produced by a toothed wheel passing under a spring catch," as Darwin described it in his *Voyage of the "Beagle."* The Green Silver-lines (*Hylophila prasinana*), of our own country, is also said to produce "a sharp quick noise." Dr. Sharp says that "sound production seems to be of more frequent occurrence in Arctiidæ than it is in any other family of Lepidoptera; *Dionychopus niveus* produces a sound by, it is believed, friction of the wings. In the case of the genera *Setina* and *Chelonia* the process is said to be peculiar to the male sex: Laboulbène believes it to proceed from drum-like vesicles situate one on each side of the base of the metathorax."

XII

BURGLARS

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BURGLARS

It may be objected possibly that the calling of a burglar scarcely entitles him to rank among artizans, but a popular dictionary, to which we have just referred to justify us if possible, defines "artizan" as one skilled in any art, mystery, or trade, and surely there is both art and mystery about the proceedings of the human burglar, and the Insect Burglar does not fall short of her human prototype in these respects. We have used the feminine gender, because, as in so much that we have had to tell, it is the female insect that does all the clever work. The male insect, apart from his often finer appearance, is a poor creature.

Just as the human burglar is a product of civilization, so, too, the Insect Burglar is mainly to be found in what is considered the most highly evolved order of the Insects—the Hymenoptera, the order that includes the Ants, the Wasps, and the Bees. Strictly speaking, however, these dishonest insects should be classed as Housebreakers rather than Burglars, because they are daylight operators; but in non-legal modern parlance the term "house-

breaker" has become almost restricted to those who demolish effete buildings, so that the word chosen will scarcely mislead any one.

In our chapters on Masons and Miners we have dealt with the clever work accomplished by a number of insects in the hope that their progeny might develop in peace behind the strong outworks they have laboured to prepare, and enjoy the abundant food they have provided. But in numbers of cases the operations of the mother insect have been watched, and at the right moment the criminal watcher has popped in and laid her own egg before the cell has been sealed up. It is as well that the industrious bee or wasp knows nothing of what has happened, for in the result much of her patient labour has been thrown away, for no good to her own species can come of it—only benefit to the enemy of her race.

There are numbers of the criminal classes of insects who secure the success of their progeny by planting their eggs in the bodies of other insects, and these foster-parents are destroyed by the grub of the parasite. With these, at present, we have no concern, and must restrict our attention to those that actually break into the nests of honest and industrious labourers.

In summer time we may often see sitting upon a wall or a leaf in full sunshine a little "fly" of very brilliant appearance, its hind body especially being highly polished, of a ruby tint, with a metallic shine that makes it look like a little ball of fire.

It is one of the Ruby-tail Wasps, and probably the species distinguished as *Chrysis ignita.* Although it appears to have nothing to occupy its mind, and is apparently spending its winged existence in an easy-going manner, it is probably on the watch. Possibly you have not noticed that on the wall, not far from the position the Ruby-tail Wasp has taken up, a Mason Wasp (*Odynerus parietum*) has half finished the construction of her nest.

As we have shown in an earlier chapter (see page 77), the Mason Wasp provisions her cells with little caterpillars, and when the cell is nearly full the Ruby-tail watches the Mason go off for, perhaps, the last caterpillar. Into the cell she then drops one of her own eggs, and the Mason returning, seals up the cell. What happens? Dr. Chapman watched this performance, and two days after the cell had been closed he opened it. The *Chrysis* egg had hatched and the grub that had issued from it was already a quarter of an inch long; but there was no sign of the Mason Wasp's egg or grub. The presumption is that the *Chrysis* grub had eaten it. Thereafter the latter feasted on the caterpillars that had been stored for the sustenance of the Mason's offspring. In six days all were eaten, and the *Chrysis* grub, after moulting three or four times, had reached its full size; so it spun a cocoon and became a chrysalis.

According to other observers it is usual for the Ruby Wasp grub to wait until the Mason's grub has grown, and to feed upon that without touching

the store of caterpillars. But there are various species of Ruby Wasp, and they are known to differ somewhat in their habits. *Chrysis bidentata*, for example, looks out for a nest of the turret-building Mason Wasp (*Odynerus spinipes*), and if it can find a chink in the masonry that closes the mouth of the tunnel it gets its eggs inside. It was mainly with the idea of keeping off this foe that the Mason Wasp built the tower we have previously described (page 71), from which she obtained the materials to close the mouth of her nest.

The remarkable point is that the Ruby Wasp is said by some strange sense to ascertain at what stage the Mason's grub has arrived. She desires a grub that has reached full size and has spun its cocoon. Having satisfied herself that she has got an unseen victim in that condition, she deposits several eggs, though only one hatches. Here again there is a mystery. Why should six or ten eggs be laid and only one hatch ? Yet it is said to be so, and that the *Chrysis* grub attaches itself to the skin of the Mason grub and sucks at it for about eleven days. By that time it is an empty skin, and the *Chrysis* grub having reached its full size spins its own cocoon inside that of its victim and remains there till the following spring. Then it becomes a chrysalis, and about three weeks later it comes forth as a brilliant Ruby Wasp to victimize some other Mason—that is, if it be a female.

Bembex rostrata is a solitary wasp that, instead of filling up its cells with sufficient food to last the

grub to full growth, deposits a single gad-fly with her egg. This necessitates her return after a few days with fresh supplies, and a relation of the Ruby Wasp, named *Parnopes carnea*, having learned all about the habits of *Bembex*, waits for this re-opening of the nest and slips in to deposit an egg of her own. The *Parnopes* grub feeds on the *Bembex* grub, and the mother *Bembex* continues to bring freshly killed flies at the proper intervals and never appears to suspect that she is nourishing the murderer of her own offspring.

The experiences of the Mason Wasp are paralleled by those of the Mason Bee (*Chalicodoma muraria*). This bee, as we have seen (page 67) constructs its cells of hard cement, in a cluster, and fills up the spaces between and evens up the exterior by more masonry. About the beginning of August when the Mason Bee's grubs should be full-grown and about to turn into pupæ, a Chalcid (*Leucospis gigas*), got up with bands of black and yellow to look like a wasp, comes along and makes a careful survey of the mass of masonry. There is absolutely no indication from without where the cells are situated within, and how the *Leucospis* locates their position is a great mystery—but she does it.

From the end of her hind body there is a long boring apparatus and egg-placer combined. This when not in use is kept in a groove along the back; but now that she has satisfied herself as to the position of the bee's cells, its position is reversed, and it is gradually thrust through the strong

masonry. The time required for this operation depends upon the thickness of the masonry at the spot selected. It may be accomplished in a quarter of an hour; it may take three hours! Fabre has watched this burglar at her work, and marked her incision of the masonry and put the date against it. On opening the nests later he has found that she has invariably hit upon the right spot and has penetrated to a cell.

But although she has this marvellous sense, a sort of second-sight, that enables her to see, as it were, what lies on the other side of the masonry, it is disappointing to find that in one respect her sense is defective. It cannot tell her that in some of the cells her intended prey has already perished and its food-supply dried up or gone mouldy. Nor does it protect her from making the mistake of piercing a cell that has already been penetrated, once, twice, or thrice, either by herself or another of her kind. Perhaps it is a necessity of the case, in order that some *Chalicodoma* grubs should survive and come to the winged state. For it must be explained that if a *Leucospis* egg hatches and brings forth a grub, that grub sucks the rightful occupant of the cell and leaves only an empty shrivelled skin.

In those cases where several *Leucospis* eggs have been placed in one cell, it is the care of the first-hatched grub to search for the other eggs and destroy them, for a *Chalicodoma* grub only serves for the nourishment of one *Leucospis*.

There are a number of parasitical insects of this order known as Ichneumon Wasps, which deposit their eggs in or on the caterpillars of butterflies and moths. These we take no notice of at present, because they are not burglars. Some, however, are entitled to be so called, because the female with her long egg-placer pierces the walls of a tough cocoon and lays its egg in the contained chrysalis. Some of these appear to be as gifted as *Leucospis* in finding the exact location of their hidden victim. Thus, Ratzeburg saw a species of *Pimpla* piercing a leaf with its ovipositor. This looked at first sight as though *Pimpla* had changed its habits and was laying eggs in vegetable instead of animal substances; but on looking beneath the leaf a cocoon of the Lackey Moth was seen to be attached to the under side, and though *Pimpla* could not see this she knew by some other sense just where to strike. A similar sense is possessed by other Ichneumon Wasps that bore through solid wood in order to deposit their eggs in wood-boring caterpillars.

Under the head of Carpenters we have mentioned (page 123) how the grub of the Horn-tail Wasp (*Sirex*) feeds in the solid wood of pine-trees. *Rhyssa persuasoria* is a large Ichneumon Wasp whose grub lives at the expense of the *Sirex* grub, and to reach the latter in its retreat the mother *Rhyssa* is provided with a delicate boring apparatus that is three or four inches in length.

There are two remarkable things to be pointed

out in this connection. The first is the possibility of so fine an instrument being capable of piercing solid wood; the second is the exactitude with which the boring is made so that an egg can be placed right in the tunnel of the *Sirex*. Unless this could be accomplished all the labour of boring would be in vain. Unless the *Rhyssa* grub on hatching is in a position to get quickly to its prey it must perish. It may happen that whilst the *Rhyssa* is feeding upon its victim the *Sirex* grub burrows deeply into the wood; but having passed through the intervening stages to the winged condition it is then able to excavate a direct way out to the air by means of its jaws.

It is somewhat sad to relate that some species of the honourable family of bees have fallen into evil courses and are now to be reckoned permanently among the insect criminal class. The bees of the genus *Osmia* are industrious little insects that construct their cells in blackberry-stems, empty snail-shells, and similar retreats. *Osmia leucomelana* when busy burrowing the blackberry-stem is watched by another bee, *Stelis minuta*; and when *Osmia* is piling up her provisions *Stelis* slips in and deposits an egg long before the heap is complete. *Osmia's* own egg is not laid until the cell is fully provisioned and ready for sealing up; so that the *Stelis* egg hatches first, and the two grubs (*Stelis* and *Osmia*) are at opposite ends of the pollen-mass. Ultimately, when the pollen is consumed they meet, and *Stelis*, having always the

PLATE 38 TWO ICHNEUMON-WASPS. Page 280

These large Ichneumons—here shown of the natural size—lay their eggs in the bodies of wood-boring grubs, and in order to reach these are said to actually bore through solid wood, in one case with the hind-body and in the other with the hair-like appendage thereto. The first—Rhyssa—is a native of Britain; the second—Pelecinus—is an American species.

Photos by Author.

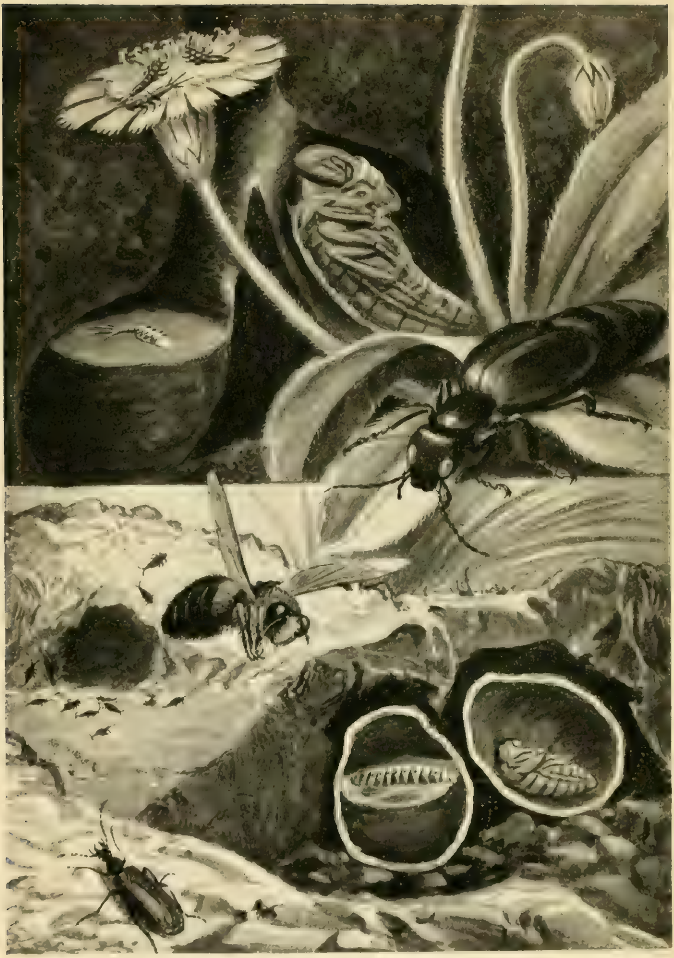

PLATE 39 THE OIL-BEETLE AND THE SITARIS. Page 296

Above the newly hatched grubs of the Oil-beetle are waiting on the flower for a bee to convey them to its nest. Just below it a grub is in the bee's cell, clinging to an egg floating on honey. In another cell the chrysalis is awaiting its final change. The lower half of the picture shows similar stages in the history of the Sitaris-beetle.

Drawn by T. Carreras.

advantage of age and bulk, overpowers *Osmia* and eats him.

The Nomad Bees (*Nomada*) in a similar way enter the earth-burrows of *Andrena* (page 21), and deposit there eggs in her uncompleted cells, with a similar result ; and *Melecta* plays much the same part in the burrows of *Anthophora*.

The Mason Bee (*Chalicodoma*), previously referred to, has a hard struggle to maintain its existence, for no fewer than sixteen different species of burglars have been found in its cells, including *Leucospis*. A few of these, it is suspected, may turn out to be detectives on the track of the burglars, but when allowance has been made for that probability the effect of the industry of the others in checking the reproduction of the hard-working Mason are appalling.

Fabre broke up one of the masses of masonry which comprised nine cells, and found only one that had not been criminally entered by an enemy. In these eight cells the proper occupant had either been eaten by the burglar or had been starved to death owing to the interloper having consumed its stores of food. Three had fallen victims to the grub of a two-winged fly (*Anthrax trifasciata*), the others to enemies of its own class, including *Leucospis* (two), *Stelis* (two), and *Dioxys* (one).

The latter Chalcid has been noticed flying around and making observations during the building operations ; and it is believed that when the Mason has gone off for a further supply of pollen, *Dioxys* has

deposited an egg in the pollen-mass. This egg hatching soon after the cell has been sealed up, the *Dioxys* larva has avoided further trouble by eating the Mason's egg and then consuming the provisions. High as is the percentage of destruction in the case cited, it is not the worst, for Fabre says he has frequently examined nests without finding a single cell that had not been attacked by one or other of these parasites.

Colletes is a small hairy bee, in general appearance somewhat like the Honey Bee. It burrows into hard sandy banks, and in the burrows constructs its cells. There is a small group of other bees named *Epeolus* which exist solely at the expense of *Colletes*, and they have adopted a rather "cute" way of locating their victim's nest without the fag of searching for it. *Epeolus variegatus* has discovered that *Colletes daviesanus* has a fondness for the pollen of tansy. So *Epeolus* frequents the tansy flowers, and when *Colletes* comes along to get another supply of pollen it is easy to shadow her to her nest, get in as soon as her back is turned, and leave the fatal eggs behind.

Then there are several species of *Cœlioxys* of similar marauding habits, and they prey chiefly upon the Upholsterer Bees (*Megachile*), also upon *Osmia*. Friese says that when *Cœlioxys* sees the rightful owner of the nest returning with a fresh supply of pollen she seeks to get out of the way and not be seen; but it is a characteristic of all these burglars not to act in a way that is likely

to arouse suspicion or resentment. One can even imagine them asking a polite question as to the progress of the work, and indulging in a little judicious flattery as to the perfect manner in which it is being carried out.

It is contended by some authors that the victimized bee would never suspect that anything was wrong, even if she caught the interloper in the act of depositing eggs, and would only experience annoyance from a stranger being present and possibly getting in her way. Some observers have stated that if a bee returns and finds a stranger in her burrow, she politely withdraws to give the intruder an opportunity for departing. It is contended that the artizan having no knowledge of what happens to her offspring after she has sealed up her cells cannot have any fear—even if she sees a strange egg on her store—that anything can interfere with the due course of development. It may be so, but one feels that if there is anything in "instinct" it is here it would come into play to warn the parent.

Such relationships as we have mentioned are quite common between different species of the Hymenoptera; but some of them are so much like those we have described that our readers would scarcely thank us for going into details with the others. Several, however, we must mention briefly. The industrious bees that laboriously gather pollen—not for their own use, but in order that their unseen progeny may have sufficient food to last

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them through their larval stage—are characterized by a special arrangement of the hind pair of legs, the shank being flattened or hollowed and fringed with stiff hairs which convert it into a basket in which the closely packed pollen can be carried home.

The bees who act as cuckoos have no such provision, and it is a nice point whether their present depraved status is due to the persistence in evil courses of their ancestors, or whether the niggardliness of Nature is responsible for their depravity. On the one hand it may be that originally they were fitted out with pollen-baskets, but that the continued non-use of them caused these to dwindle and ultimately disappear. On the other hand they may have been at the beginning what they are now, in which case it would be unreasonable to find fault with their dishonest mode of life.

Before much was known of the actual habits of these bees it was assumed from the absence of the pollen-baskets that they were parasites. Then in the case of the genus *Sphecodes*, which has an incipient pollen-basket, it was variously suggested that this was the beginning of a better condition of affairs, and that it was the last survival of what was once upon a time in the history of the race a properly developed basket. To give point to the first view it was stated that some of them had been observed burrowing on their own account. It may be that they do at times strive after a better mode of life, for which at present they are ill-fitted, but on

the whole there can be no doubt that their prevailing habit is to have their young brought up at the expense of the burrowing bees *Andrena* and *Halictus.*

A more remarkable case is that of the Humble Bees (*Bombus*) and the Cuckoo Bees (*Psithyrus*). Here the two tribes are so much alike in size, clothing, and colouring that only an expert can tell you which is which. But if one examines the hind legs of the two the difference is at once manifest in the presence and absence of the pollen-basket respectively. It was formerly thought that these Cuckoo Bees—of which we have five species—were merely messmates of the Humble Bees, in some way making return for their food and lodging; but there can be no doubt that they are actual parasites, thriving at the Humble Bee's expense, and bringing about the deterioration or absolute ruin of the colony.

The Cuckoo Bees are all males and females: there is no worker class. Each species in colour mimics that species of Humble Bee upon which it preys, but is usually somewhat larger. Why there should be this mimicry is not clear, for it does not impose upon the Humble Bee. The mother of the colony detects the cheat, and in some species attempts to eject the intruder. But this appears always to result in the Humble Bee being killed, and the progress of the colony being checked, of course. This is apparently the Cuckoo's object. She helps herself to the contents of the honey-pot.

and with the Humble Bee's wax constructs cells for her own eggs. Her grubs have to be fed by the exertions of the Humble Bee workers, and the mother of the colony being dead, there are no more Humble Bee eggs to develop into more workers. The presence of cocoons belonging to the Cuckoo Bees in the combs of *Bombus* can always be detected by their larger size.

The Humble Bees have other intruders in their nests. Among them in this country is a curious creature (*Mutilla*) whose wingless female in form much resembles a large ant, but its hairy covering, brightly coloured, gives it a likeness to a bee. Its affinities are really closer with the digging wasps (*Fossores*). They are very rarely seen, except by those whose studies lead them to explore the nests of wild bees. The wingless female with eggs to lay crawls into the nest of the Humble Bee, finds out the bee-grub in its cell, and, it is supposed, pierces the body of the grub and lays an egg inside it.

In about three days the egg hatches and the *Mutilla* gradually consumes the bee larva, and when it has completed its destructive work it spins a cocoon inside the skin of its victim. When it has run through its course and arrived at the ultimate stage, if a male, it soon leaves the nest; but the females regale themselves at the Humble Bee's honey-pot before seeking adventures outside.

Another burrowing wasp (*Sapyga*) instead of making a burrow for itself, as its kindred do, takes

possession of the burrows that the solitary bee *Osmia* has made in a bramble-stem. It lays its eggs there, and the young *Sapyga* grub begins life by eating the egg of *Osmia*, and thereafter consumes the provisions laid up by the bee.

Some of the parasitic wasps confine their depredations to the nests of other wasps. Thus *Pompilus*, one of the Spider-hunting Wasps (see page 29), has its nest invaded by a relative named *Ceropales*, who lays an egg on the freshly brought in spider, and so anticipates *Pompilus*' own egg-laying. More frequently *Ceropales*, like *Epeolus*, saves herself the trouble of hunting out *Pompilus*' nest by watching *Pompilus* when she is stalking spiders. When she has secured her prey and is flying heavily home with it, *Ceropales*, flying light, overtakes and lays an egg upon the burden. One is inclined to sympathize with *Pompilus* in this matter, but some observations of Ferton's tend to withhold our pity and make us exclaim "*arcades ambo*"; for he says that when *Pompilus* has caught a spider, one of her own tribe may come along and despoil her of it forcibly.

Larrada australis waits until *Sceliphron lætus*, one of the Mud-dauber Wasps (see page 81), has made her mud-cell and provisioned it, and then—under the eyes of the builder—proceeds to partition off part of the cell and its food-supply in which she lays her own egg. It is to be presumed that the *Larrada* grub eats up the *Sceliphron* grub. Whittell says there is a little preliminary skirmishing between

householder and burglar, as if each were doubtful of the attitude of the other, but it ends in *Sceliphron* allowing *Larrada* to carry out her plan. This looks like another failure of instinct. There is no room for reasoning in the matter, for none of these wasps has any inherited knowledge of what happens to her offspring, and the grub that suffers from such dishonest proceedings never survives to transmit the knowledge to descendants.

Perhaps one of the most audacious examples of these burglarious practices is afforded by the habitual, everyday conduct of the little yellow ant *Solenopsis fugax*. This ant seeks out a nest of *Formica fusca*, an ant twice its size, and constructs its own galleries in the walls of *fusca's* habitation. From these galleries it makes entrances into the chambers of the larger ant and lives cheaply at the expense of *Formica* on its grubs and chrysalides. It might be inquired, why do the larger ants permit this? There appears to be only one reason, and that is that their superior size puts them at a disadvantage. When in danger of being caught the smaller ants slip through their minute holes and tunnels where *Formica* cannot follow them. Forel says that these entrances and exits are so carefully contrived that they only just permit the passage of the *Solenopsis*.

One might suppose that from living for generations in such close proximity, some sort of friendliness would have been established between the two species; but that is not so. When they chance to

meet, the individuals of the two races fight furiously, in which the small size of the burglar is compensated by the possession of a sting.

The cunning of the *Solenopsis* is curiously like the operations of the scientific human burglars, who, having ascertained that certain business premises are worth looting, rent some adjoining property and then quietly cut through the intervening walls or tunnel under the basement to effect a secret entry that will give them access to the treasures of the more industrious firm.

One of the burrowing wasps (*Tachytes*), that provisions its nest with stung Mantis, has its labours for its prospective progeny destroyed by the grub of one of the Blister Beetles (*Cerocoma schæfferi*), which eats up the provisions and so starves the wasp grub. This is not the only beetle given to such nefarious practices. There are two that belong to this same family of Blister Beetles that have long been known to victimize solitary bees of the genus *Anthophora* (see page 27), and another one of a neighbouring family that acts in a similar unfriendly way to the Social Wasps.

The methods of the two first (*Sitaris* and *Meloë*) are so astonishing that a recital of them must appear to the ordinary reader, unused to the strange ways of Nature, as a bit of Munchausen literature. At the same time they afford an interesting commentary upon "unerring instinct"—and other matters. Here, briefly put, is the story of the Oil Beetles (*Meloë*). There are numerous species—

seven are known to the collector of British beetles —and a common species may frequently be seen in spring dragging its bloated blue-black body across country paths. It is probably a female seeking for a favourable spot in which to deposit her eggs. These she plants in batches in holes in the ground, and it is calculated that her total output of eggs amounts to about ten thousand.

Now, seeing that these beetles exude an unpleasant oil-like yellow secretion from their joints which renders them objectionable to creatures that feed upon insects, there does not at first sight appear to be any need for such lavish fruitfulness. What becomes of this progeny? The Oil Beetles are not insects that appear in swarms. It is estimated that only one in a thousand gets beyond the first larval stage. We should say that the estimate is too high, for we do not find the species any more plentiful to-day than we found it forty years ago. What becomes of the nine thousand nine hundred and ninety-odd will appear, and give point to Tennyson's lines on Nature:

> "So careful of the type, she seems;
> So careless of the single life."

The Oil Beetle's eggs hatch and give origin to larvæ that have little likeness to the usual types of beetle-grubs. They have six long legs, and are quite active little runners and climbers. They are long-bodied, but this length only extends to about one-tenth of an inch. As soon as they have escaped

from the egg-shells and the earth, they start climbing the stems of flowering plants, and continue until they have reached the flower. Here they wait patiently until some other insect visits that flower in quest of nectar or pollen. When such a visitor arrives the larva at once clings to its body, and is carried away unnoticed.

This larva is called a triungulin, because each of its six feet ends in three claws, and it appears to be formed solely with a view to this indispensable act of its life—the clinging to a particular kind of bee. But it is here that its instinct fails. In order that it may justify its existence it should cling only to a bee of the genus *Anthophora*. As a matter of fact, it will cling to any insect that is sufficiently hairy to enable its hooked feet to hold on. Unless it catches the right bee it perishes, the success of the operation depending upon the triungulin being conveyed to the bee's nest.

Let us suppose that the particular individual in which we are interested has boarded the right bus, so to speak, and arrived in the burrow of the *Anthophora*, where there is a cell fully provisioned with honey, upon which the bee now deposits a floating egg. The triungulin is waiting for this act, and before the bee has time to seal up the cell it slips off the bee and balances itself nicely upon the bee's egg.

At this stage of existence it is incapable of feeding upon honey; the one thing that it appears able to take in the way of nourishment is the bee's egg, and this it devours. The egg of a bee may appear

to be a very small matter, but it serves the triungulin for several days; and then the insect casts its first skin and appears in a different form. It now more closely resembles the grub of the cockchafer, and is capable of floating on the honey and of feeding upon it. But how many of its kindred, hatched from the multitudinous eggs of the same mother beetle, have perished! In due time it consumes all the honey, changes into a chrysalis, and finally into a perfect Oil Beetle.

There is another beetle—rare in this country—named *Sitaris*, which curiously goes through a similar experience, also in connection with an *Anthophora* bee. It is more plentiful in the South of France than it is with us, and Fabre has managed to work out its life-history with tolerable completeness, a matter of considerable difficulty, as will be understood from the following brief statement:

Sitaris humeralis is not so prolific as *Meloë*, but she lays at least two thousand eggs, and takes care to place them in the ground very near to the burrows of *Anthophora*. This happens some time in August, and the eggs hatch about the end of September. There are well-stored honey-cells close at hand, and one would expect that the little black *Sitaris* triungulins would at once go to them and begin feeding. But the sensation of hunger is at present unknown to them; they simply huddle together and pass the winter where they were born.

In spring—about April or May—they wake up, and begin to look about them. Should any hairy insect come within reach they seize upon it, whether it be bee, fly, or beetle, and as a result the vast majority fail to proceed farther on their proper way of life. The first of the new *Anthophoras* to issue from their cells are males; and as these hang about in the burrows for a few days until their wings and integuments have hardened properly, a number of the *Sitaris* triungulins have a good opportunity for attaching themselves, and they take advantage of it.

But they appear to know that they have not yet got hold of the insect that can directly help them to work out their destiny. About a month later the female bees emerge, and as these are being courted by the males, the triungulins contrive to transfer themselves from one to the other. The females busy themselves, of course, in the making of cells, and the triungulin, knowing that it has reached its destination, gets off as soon as the bee lays an egg on the store of honey.

The cell is sealed up, and the little *Sitaris* commences to feed upon the egg. This repast lasts about eight days, and then it casts its skin, and emerges as a very different creature, with exceedingly short legs and a shortened inflated body which enables it to float on the honey with safety. Its spiracles or breathing-holes are placed along each side of the back, instead of along the sides as usual in larvæ, so that it can breathe without risk of

the spiracles becoming clogged. The only exertion demanded of it is the sucking up of the honey, and there is enough of this to occupy it for about forty days.

This brings it to the middle of July, when it changes again, becoming much like the puparium of a fly. In this condition it may remain for a month, or for eight months. Those of the shorter period return to much the same condition as that in which they consumed the honey. A little later it becomes a chrysalis, and in August or September it emerges as a *Sitaris* beetle. The tardy individuals pass the winter in the false pupal condition, and finish their changes in spring. This, it will be seen, is one of the most complicated and remarkable of insect life-histories.

XIII

LAMP-BEARERS

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Though the bearers of lights produced and maintained by their own vital chemistry are common enough among creatures of the sea, they are exceedingly rare upon land. The ocean has many back-boned light-bearers in the luminous fishes of the deeps, but no terrestrial back-boned animal has such power. The Lamp-bearers of the land are all small invertebrate animals, and with very few exceptions they are beetles. A hundred years ago it was believed that there were others among the bugs—the so-called Lantern Flies—but the belief has long been given up; though science has embalmed the error in their Latin name *Fulgora.*

The name of our Glow-worm (*Lampyris noctiluca*) will at once arise to the mind of any reader who has met with the male insect, and knows therefore that it is a beetle, and not a worm, as the unfortunate folk-name leads many to suppose. This misconception is due, of course, to the fact that the female, who carries a far more powerful lamp than her mate, is not merely wingless, but lacks also the wing-covers which many wingless

beetles are endowed with, as though to give them an air of respectability and prevent their being included in a lower class.

The female Glow-worm is certainly not like any terrestrial worm, though in the sea we could find specimens that would justify the comparison. She is soft and depressed, and her back shows plainly the segments of her structure. On the under side of her hind body and near to its extremity are three light-giving patches on each side. During the daytime she remains hidden among the grass and moss of hedgebanks, feeding upon snails, which she literally "eats out of house and home."

In the evening she temporarily leaves her repast and climbs up the stem of some weed in order that her lamps shall be raised just above the grass, and gives a twist to her hind body so that the light may be more fully revealed to the world in general, and perhaps to the other sex of her own kind more particularly. This is not the universal opinion of its use, some authorities pointing out that there are thousands of nocturnal creatures who contrive to find partners without any such aid. That is so; but seeing that in this case the female is wingless and unable to drag herself far from her feeding-ground, it is at least feasible that the luminosity is made use of by the species for this purpose.

It may be stated that no better explanation has yet been offered. Opponents of this view point out that some other reason is indicated by the fact that the larva is also luminous, and not only

the larva, but the pupa and egg as well. It is quite certain that in neither of these stages can the insect make use of luminosity in this connection; but, as Messrs. Priske and Main point out, "there are instances in other animals of organs present in the male and immature forms which are only functional in the mature female."

The male also has a small degree of light, but his lamps are no bigger than pin-heads. Now, it appears to us that if the females' light were not for the purpose of attracting the male, the latter would give as brilliant a display as his partner.

Besides, if you compare the eyes of the two sexes, you will see that whilst those of the female are small, those of the male are so highly developed that almost the whole of his head consists of his large eyes. Are not these eyes developed to a far greater extent than those of the female in order that he may the better see where her light is shining? He is certainly attracted by light in a manner that other of our native beetles are not; and we have witnessed male Glow-worms flocking by scores through an open window because a bright lamp shone within. Till then we had never imagined the Glow-worm was at all plentiful in that district, and the impression we formed was that they had all taken the lamp to be a fine and very luminous female.

In connection with the difference in the eyes of the two sexes noted above, Dimmock says: "When one sex of any species of Lampyridæ emits intenser

light than the other sex, the less luminous sex has, as a rule, the best developed eyes; this is especially marked in the case of the large eyes of males of species in which the female is luminous, but apterous."

There is very little difference in the appearance of the larvæ and the fully developed females. From the laying of the egg to the emergence of the perfect insect from the chrysalis a period of about twenty-one months is covered, the insects becoming inactive during winter. Both larvæ and perfect insects feed upon snails and slugs. Such creatures when attacked exude a great amount of slime, and the larva has a special implement for dealing with this when it has got smeared over its body. Such a coating might seriously interfere with the proper action of the breathing apparatus by closing some of the spiracles; but from the last segment of its body the insect can protrude a bunch of whitish filaments which it uses as a brush by curving the flexible hind body and drawing the brush over the soiled part.

As to the nature of the luminosity of the Glow-worm and other Lamp-bearers, there is much difference of opinion among the authorities. One says it is due to the slow oxidation of a special substance in the cells of the light-giving region, controlled by the nervous system. Another says he has found in the Fire-fly that it is due to the reaction of two substances called luciferase and luciferine, the former found only in the luminous

organs and the latter in the blood, and the entry of blood into these organs produces the manifestation. It may be pointed out, however, that neither of these explanations will account for the luminosity of the egg, where there are neither air-tubes nor blood-vessels.

Whatever be the true explanation of its chemistry, it is certain that the exhibition is under the control of the insect, as may be proved on capturing an individual. Gilbert White was of opinion that the Glow-worm puts out her light between eleven and twelve o'clock at night; and although no modern observer appears to have taken the trouble to check this statement, it is quite probable, for many nocturnal insects have definite hours of flight, and if the male Glow-worm ceases to fly about that hour one might expect the female to conserve her light by switching it off at the time when the experience of the race has proved it to be ineffectual. This, of course, presumes again that the light is of sexual importance.

On this point, as to the reason for the luminescence, it should be mentioned that Mr. Belt contended that it was protective. He found that the insects were distasteful to insectivorous mammals and birds; and, therefore, it would be an advantage to the species that their enemies should be able to recognize them at once by their light, and so avoid them. This explanation, however, does not go far enough.

It is not generally known that the Glow-worm

is not the only luminous insect that is found in Britain. There is another species which has no folk-name, but we may call it for distinction' sake the Little Glow-worm (*Phosphænus hemipterus*). The male is not uncommon in places, but the female appears to be rare. Neither sex has wings, and its light-giving powers are very feeble.

Another species which has been occasionally taken in this country, but is very plentiful in the South of Europe, is the Italian Fire-fly (*Luciola italica*). In this species—a beetle again in spite of the name—both sexes are provided with wings, but the female is altogether feebler and less highly developed than the male. This probably accounts for the fact that the female is accounted very rare, the swarms that on warm evenings in May and June display their light in the air consisting almost entirely of males. The feebler female, like our wingless Glow-worm, keeps to the herbage near the ground. The Italian Fire-fly is a little smaller than our male Glow-worm. Another European species of Glow-worm is known as *Lampyris splendidula*.

Eaton has timed the duration of the flashes of the Italian Fire-fly's light and finds that it is from a third to a fourth of a second, and that they are repeated about thirty-six times in a minute.

The strange grub-like condition of our female Glow-worm appears to be accentuated in a South American species known as *Phengodes hieronymi*. The winged male is especially noticeable on account

of its remarkable antennæ, which are developed into feather-like organs. As his eyes do not exhibit any undue development, it may be conjectured that he finds the wingless female by some other sense than sight, in which the branched antennæ assist him. The female is said to have been long known in Paraguay as the Railway Beetle, for reasons that will appear; but it is difficult to understand how any one not an entomologist could suspect that it had any connection with beetles. Railway *Worm* would be the much more likely term.

The reason for its association with railways is the allegation that along its sides it has numerous points from which a green light is produced, whilst from either end a strong red light glows. The statement as to the green lights is convincing enough, but the red lights we are not so sure of. Haase publishes a figure of one of these Railway Worms (reproduced in *Cambridge Natural History*) in which the position of the side lights is indicated, but there is no reference to the head and tail lights. These are probably not luminous spots at all, but bright-red colour-markings.

The Fire-flies of the American tropics are beetles of another family, represented in Britain by the Skipjacks or Click Beetles, of which our destructive Wire Worm is one of the larvæ. The old books of travel in the West Indies made these Fire-flies or Cucujos quite familiar to the English reader. It was not so in earlier days when Sir

Thomas Cavendish first landed in the West Indies. The idea of flying lights had not yet got abroad; so when in the evening brave Sir Thomas and his party saw lights moving in the woods they were convinced that their enemies, the Spaniards, were advancing upon them, and they sought safety in their ships.

But though the Fire-flies were unknown to Cavendish, they had already become known to literature, for Peter Martyr, who was contemporary with Columbus, has left us some account of them in his *Decades*, which Southey quoted in the notes to his *Madoc*. Peter says that in the Spanish West Indies the natives employed these living lamps instead of candles, and when abroad at night travelling, hunting or fishing, they tied a Cucujo to each big toe and needed no other light. He also says that they employed them in their houses, not only to light the apartments, but to prey upon the gnats, which were a dreadful pest. This statement is very doubtful, though made in good faith.

To capture the Cucujos the native would go out of the house at the beginning of twilight, carrying a burning fire-brand in his hand, and ascend the first hillock that his light might be better seen by the beetles. There he would swing the firebrand around and call "Cucuie, Cucuie." The simple people, Peter says, believe that the Fire-flies come in response to their call, but for his part he believes that the fire is the attraction.

On certain festival days in June the beetles were

collected in great numbers and fastened to the dress of young people and the trappings of horses, upon which the youngsters would ride through the streets after dark. On such occasions many wanton wild fellows rub their faces with parts of a freshly killed Cucujo "with purpose to meet their neighbours with a flaming countenance."

This Cucujo or Fire-fly is the *Pyrophorus noctiluca*. There are a large number of species in the genus *Pyrophorus*, but they are not all Fire-flies, though probably the majority are more or less luminous. *P. noctiluca* is the only one whose life-history has been dealt with satisfactorily. As we have said, the perfect insect is very like our Skipjack, but much larger. It measures about an inch and three-quarters in length, and is of a rusty-brown colour. On the hard shield-like crust of the fore body (*thorax*), there are two oval spots which the older writers thought were the creature's eyes, because they are luminous in the evening. But the chief source of light is on the under side at the junction of the fore body and the hind body, which is not visible except when the beetle is on the wing.

Like those of the Glow-worm, the eggs of the Cucujo are said to be luminous; and the larva has the same quality. But there is an increase of the light-bearing spots during the larval period. At first the larva has only one luminous area—just behind the head; but at a later change of skin this is supplemented by a row of luminous points along the sides above the spiracles or breathing-pores.

A minute species of Fire-fly (*Photurus pennsylvanicus*), common in the Eastern United States, has wings in both sexes. It is yellowish in colour, with a few ill-defined lines of brown or black. In the Mississippi Valley its place is taken by *Photinus pyralis*. Its larva lives upon earth-worms and soft-bodied insects, which it hunts for underground.

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